Attachment D Upper Crooked Creek Permittee Responsible Mitigation Plan

Contents

Figures

Tables

Photos

Appendices

Attachment D Upper Crooked Creek Permittee Responsible Mitigation Plan

Introduction

The proposed Donlin Gold, LLC (Donlin Gold) Project (Project) mine site is located within the Crooked Creek watershed (United States Geological Survey [USGS] 10-digit Hydrologic Unit Code [HUC] watershed 1903050108). The Crooked Creek watershed is remote and predominately undisturbed, with minimal development occurring on its landscape. The majority of existing disturbances within the watershed are in two distinct locations: the village of Crooked Creek on the Kuskokwim River, and the upper reaches of the watershed near the proposed Project area.

The disturbed areas near the proposed Project in the upper Crooked Creek watershed are concentrated in the Grouse Creek-Crooked Creek (12-digit HUC 190305010803) and Donlin Creek (12-digit HUC 190305010801) watersheds. Disturbances in these areas are primarily the result of two activities: Donlin Gold's ongoing exploration operations and historical placer mining. Placer mining has resulted in landscape-scale alterations to topography and impacts to aquatic resource functions. Placer mining impacts in the upper Crooked Creek watershed, specifically the Quartz, Snow, Ruby, and Queen Gulches, have rerouted streams from their historical channels into linear excavated ditches with no floodplains and excavated floodplains down to bedrock. Ponds, ditches, excavations, overburden fill, and side castings have all contributed to the impacts in these drainages, which include disrupted/ disconnected floodplains, lowered water tables, steep and unstable stream channels, poor water quality, steep eroding stream side slopes, loss of overlying soils, loss of vegetative cover, and narrowed hydraulic conveyances.

Based on Crooked Creek watershed fisheries habitat assessments and using the Function Based Framework for Stream Assessment and Restoration Projects (Harman et al. 2012), Donlin Gold has selected the restoration of these heavily impacted drainages as part of the Compensatory Mitigation Plan (CMP) for the Project. Using a Functional Pyramid approach from Harman et al, this Upper Crooked Creek Permittee Responsible Mitigation (PRM) Plan (Plan) defines how re-establishing the 15 functions critical to stream and riparian ecosystems will be achieved. The Functional Pyramid Approach builds on a hierarchy of processes starting with basic watershed hydrology, ascending through hydraulic processes dictated by channel, floodplain and stream sediment parameters which in turn drive geomorphic processes, sediment transport, large woody debris, and riparian vegetation to create bed form diversity and dynamic equilibrium. These building blocks are the focus of the restoration work and when accomplished correctly recreate the parameters for healthy physiochemical and biological habitats. Simply put, a correctly reconstructed stream with natural gradients, sinuosity, and properly sized and revegetated substrate, channel and floodplains will reproduce healthy aquatic and fisheries habitats.

Four distinct restoration projects are described within the 221.5 acre Upper Crooked Creek PRM Plan (Plan) boundary:

- Restoration of lower Quartz Gulch

- Restoration of lower Snow Gulch
- Restoration of the wash plant tailings area along Crooked Creek, between Snow and Ruby Gulches
- Restoration of lower Ruby and Queen Gulches

These areas are shown on Figure 1.

These restoration projects will increase the function and sustainability of the watershed and its fisheries because they:

- Re-establish and rehabilitate historical stream and wetland functions present prior to placer mining;
- Re-establish historical and establish new stream, pond, and off-channel anadromous and resident fish habitat; and
- Have a high likelihood of success to restore naturally occurring, self-sustaining systems within the Crooked Creek watershed because they are based on a stream functional framework.

All four restoration projects are located in the same 10-digit HUC watershed as the majority of the long-term and permanent aquatic resources impacts from the Project.

Objectives

The objective of this Plan is to return naturally occurring, self-sustaining wetland and stream functions to the upper Crooked Creek watershed. The Plan fulfills this objective by re-establishing floodplains and stream channels to pre-placer mining parameters using a stream functional framework and reference reaches upgradient of the impacted areas. The total benefits from this plan are presented in Table 1.

Figure 1 Upper Crooked Creek Permittee Responsible Mitigation Plan Area Overview

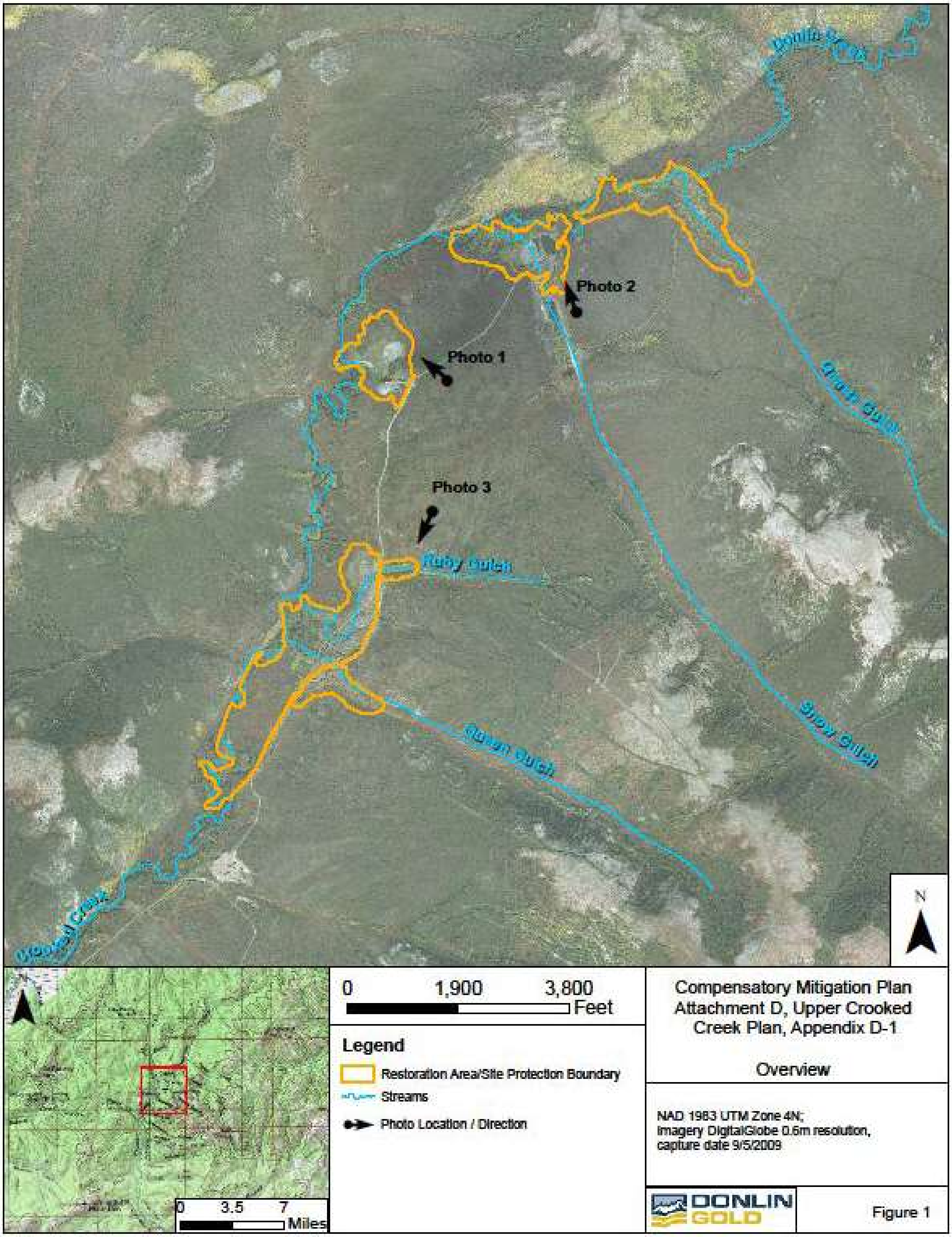


Table 1 Overview of Objectives for the Upper Crooked Creek PRM Plan Area

Restoration Activity	Expected NWI Classes	Habitat Type	Activity Description	Linear Feet	Acres
Re-establish	R3UBH, R3USC, R2UBH, R2USA	Stream Channel	Stream channels will be re-created within their natural alluvial setting to natural dimensions, patterns, and profiles.	8,982	-
Re-establish	PSS1A, PSS1C, PSS1/EM1C, PEM1C	Wetland Floodplain	Wetland floodplains will be reshaped and re-contoured into natural pre-mining configurations. These areas will be revegetated with native plant species.	-	95.7
Enhance	PUBH, PABH, PEM1H, PEM1F	Off-channel Pond (these are areas within the wetland floodplain habitat above)	Existing mining ponds will be converted into productive habitat through the creation of littoral zones and deep overwintering habitat.	-	15.2*
Enhance	U	Terrestrial	Tailings and other areas outside of the floodplain that need to be re-graded and re-contoured to support the re-establishment of floodplains will be revegetated with native species.	-	16.8
Protect	U, PSS1C, PSS1/EM1C, PEM1C, PSS1/EM1B, PSS1/4B, PSS4B, PSS4/1B, PEM1B	Buffer	Areas within a restoration buffer, plus the habitats above, will be placed under a site protection instrument to ensure the long-term performance of the restoration projects.	-	109.0
			Total for the PRM Plan Area	**8,982**	**221.5**

*Enhanced off-channel pond habitat is within the re-established wetland floodplain habitat and not included in the total acres.
"-" Not Applicable.

Historical placer mining in the Quartz, Snow, Ruby, and Queen Gulches represents a significant portion of the existing aquatic resource impacts within the Crooked Creek watershed. Restoration of these streams; floodplains; and associated wetland, upland, and buffer areas will provide a portion of the compensatory mitigation required by the United States Army Corps of Engineers (USACE) under a Department of the Army (DA) permit for the Project.

Site Selection Criteria

The Upper Crooked Creek PRM Plan were selected to provide compensatory mitigation for the Project from a wide range of potential PRM Plans identified across the Lower Kuskokwim watershed and throughout western Alaska (6-digit HUC 190305). Among all projects considered, the potential PRM Plans identified within the Crooked Creek watershed (10-digit HUC 1903050108), where the proposed Project is primarily located, were ranked highest during the site selection process. These projects were ranked highly because they restore aquatic functions and contribute to the ecological sustainability of the impacted watershed, have a high likelihood of feasibility and success, and will require limited long-term maintenance to achieve sustainability. The Upper Crooked Creek PRM Plans and restoration of some disturbed mine areas as wetlands at mine closure (see Attachment C of the CMP), were the only opportunities for mitigation identified in the Crooked Creek 10-digit HUC watershed. See Section 7.0 of the CMP for a discussion of how this Plan specifically enhances aquatic resources in the watershed.

The suitability of the PRM sites in the upper Crooked Creek watershed to provide compensatory mitigation for the proposed Project was determined based on the following factors:

1. *Hydrologic conditions, soil characteristics, and other physical and chemical characteristics* (33 CFR 332.3 (d)(i))

Previous placer mining has drastically altered the physical, hydrologic, and soil characteristics of the Crooked Creek watershed. Placer mining activities have, over time, altered the location and character of multiple tributaries to Crooked Creek. Former natural stream channels have been relocated, ditched, and diverted, and associated riverine wetland and riparian corridors have been subsequently altered or removed. These PRM Plans will reshape the altered drainages to approximate historical natural conditions in existence prior to placer mining. The projects will be supported by the natural hydrologic conditions, physical characteristics, and soil characteristics of the surrounding areas. The projects have high likelihood of success because the depth of disturbance to the hydrologic system is shallow and limited and the designs are based on pristine reference reaches within the same stream systems within the Crooked Creek watershed.

2. *Watershed-scale features, such as aquatic habitat diversity, habitat connectivity, and other landscape scale functions* (33 CFR 332.3(d)(ii))

The Upper Crooked Creek PRM Plans were selected, in part, because of the opportunity they provide to restore aquatic functions to a large hydrologically connected area and are in very close proximity to the impacts that they are targeted to offset. The projects will re-establish and re-connect the floodplains of Crooked Creek, Donlin Creek, Quartz Gulch, Snow Gulch, Ruby Gulch, and Queen Gulch, as well as restore hydrologic and ecologic connectivity between undisturbed areas upgradient and downgradient of the sites. The sizes and locations of the sites relative to each other and the larger Crooked Creek watershed contribute to their likelihood of success and long-term sustainability.

3. *The size and location of the compensatory mitigation site relative to hydrologic sources and other ecological features [33 CFR 332.3(d)(iii)]*

The hydrologic sources of these sites are perennial streams and their associated drainage basins, relying on natural existing hydrology patterns. The projects do not require active engineering devices to provide the site hydrology, increasing the likelihood of success.

4. *Compatibility with adjacent land use uses and watershed management plans [33 CFR 332.3(d)(iv)]*

While there is no watershed management plan for the Plan area, the proposed sites are consistent with the Alaska Department of Natural Resources (ADNR) Kuskokwim Area Plan for State Lands (1988), a goal of which is to: "protect the hydrologic, habitat, and recreational values of important public wetlands."

5. *Reasonably foreseeable effects the compensatory mitigation project will have on ecologically important aquatic or terrestrial resources, cultural sites, or habitat for federally- or state-listed threatened and endangered species* (33 CFR 332.3(d)(v))

The upper Crooked Creek watershed contains streams, wetlands, floodplains, and riparian resources that have been adversely impacted by historical placer mining. If these areas are not restored, they will continue to be sources of sediment and erosion, and a likely place for invasive plant species to establish. These PRM Plans will restore natural vegetation, increase aquatic habitat diversity and connectivity, establish floodplain habitat, provide habitat for ecologically important wildlife species (e.g., salmonids), and maintain water quality.

6. *Other relevant factors including, but not limited to, development trends, anticipated land use changes, habitat status and trends, the relative locations of the impact and mitigation sites in the stream network, local or regional goals for the restoration or protection of particular habitat types or functions (e.g., re-establishment of habitat corridors or habitat for species of concern), water quality goals, floodplain management goals, and the relative potential for chemical contamination of the aquatic resources* [33 CFR 332.3(d)(vi)]

The PRM Plans will re-establish floodplain habitat and reduce the current sedimentation impacts to downstream aquatic ecosystems. Connection of naturalized stream and floodplain habitats to natural conditions upgradient and downgradient of the projects will result in a higher functioning and more resilient watershed. These sites are within the Crooked Creek watershed, which is the same 10-digit HUC watershed as the primary long-term aquatic resource impacts from the Project.

Site Protection Instrument

Donlin Gold will supply a detailed site protection instrument through a deed restriction acceptable to the USACE in advance of restoration activities. Donlin Gold has the concurrence of the surface landowner (The Kuskokwim Corporation), the subsurface landowner (Calista Corporation), and the leaseholder (the Lyman Family) to establish a site protection instrument following restoration activities. The following activities will be strictly prohibited by the site protection instrument:

- Any excavation of soils, sediments, and other substrates with the exception of any that may be related to approved habitat enhancement projects (i.e., building additional wetland or fish habitat);
- Construction of durable structures, both permanent and temporary;
- Disturbance of soil, sediment, and other substrates by mechanical equipment and transportation vehicles, except on the existing access roads;
- Mining and mining-related activities;
- Vegetation removal, clearing, cutting, or other impacts, except for subsistence food uses; and

- Storage, abandonment, stockpiling, or disposal of any earthen materials, debris, refuse, supplies, durable materials, or other manmade objects.

The Plan area, which totals 221.5 acres, will be protected under the site protection instrument (Table 2). The site protection instrument will cover the areas directly impacted by the proposed re-establishment, establishment, and rehabilitation activities as well as buffer areas to help maintain the long-term viability of the proposed projects.

Table 2 Upper Crooked Creek PRM Plan Areas Protected Under the Site Protection Instrument (Acres)

Restoration Area	Acres
Quartz Gulch	45.2
Snow Gulch	36.7
Wash Plant Tailings Area	29.3
Ruby and Queen Gulches	110.3
Total	**221.5**

Baseline Information

Historical Placer Mining

Historical gold placer mining has occurred in the proposed restoration areas since the early twentieth century. Placer tailings and overburden have been deposited in several locations within the various floodplains, causing adverse impacts to aquatic resources (Photo 1). Water diversion ditches were constructed, resulting in the channeling of surface and shallow groundwater flow from the original stream paths. An estimated 8,700 linear feet (1.64 miles) of stream channels have been mined and the abutting wetlands degraded. No placer mining is currently ongoing in any of the drainages. Photo 2 and Photo 3 show placer disturbance in lower Snow, Ruby, and Queen Gulches.

Photo 1 Placer Mining Wash Plant Tailings Area (View toward Northwest)

Photo 2 Lower Snow Gulch Placer Disturbance (View toward North)

Photo 3 Lower Ruby and Lower Queen Gulches Placer Disturbance (View toward Southwest)

Hydrology

Hydrology at the proposed restoration sites is controlled by Crooked Creek, Donlin Creek, and the following tributaries: Quartz Gulch, Snow Gulch, Ruby Gulch, and Queen Gulch. Quartz and Snow Gulches flow into Donlin Creek. Donlin Creek, Ruby Gulch, and Queen Gulch flow into Crooked Creek. Quartz, Snow, Ruby, and Queen Gulches have been extensively degraded in their lower reaches from placer mining activity. Watershed characteristics of these streams are included in Table 3.

Table 3 Watershed Characteristics of Crooked Creek Watershed Streams

Drainage Basin	Crooked Creek Watershed (Percent)	Drainage Area (Square Miles)	Channel Length (Miles)	Slope (Percent)	Sinuosity	Dominant Rosgen Type	Dominant Substrate in Riffles	Average Wetted Width (Feet)
Quartz Gulch	0.35	1.2	4	3.2	1.03	G3g	gravel/cobble	8
Snow Gulch	1.01	3.4	2.6	1.9	1.04	G6	sand	4.4
Ruby Gulch	0.15	0.34	1	4.2	1.16	G3g	gravel/cobble	6
Queen Gulch	0.21	0.7	1.6	2.6	1.01	G3g	sand/gravel	6.6
Donlin Creek	9.09	30.5	16.7	0.4	1.82	B5c	gravel	19.9
Crooked Creek	100	335.5	33.4	0.2	1.62	C4	gravel/cobble	~60

Sources: OtterTail 2012, Rosgen and Silvey 2006, USGS 2017

Quartz Gulch is a small, high-gradient drainage with an area of 1.2 square miles. This drainage has been extensively placer mined in its lower end, and silt from this area continues to be transported into Donlin Creek during high storm events.

Snow Gulch is a small tributary of Donlin Creek. The Snow Gulch drainage area is 3.4 square miles with a main channel length of 2.6 miles and mean basin elevation of 1,015 feet. The lower end of the Snow Gulch drainage has been extensively placer mined and rerouted, but above the existing mined area the stream is essentially undisturbed (OtterTail 2012). The upgradient undisturbed portion of Snow Gulch Creek varies from a deeply incised channel with silt substrates to meandering sections with gravel substrates and beaver activity.

Ruby Gulch is the smallest drainage in the Plan area, draining 0.34 square miles. The downstream end has been extensively placer mined. All the flow from Ruby Gulch flows into a series of ponds, which also receive flows from Queen Gulch, formed from previous mining.

Queen Gulch drains an area of 0.7 square miles. The lower end of Queen Gulch has been severely disturbed by placer mining. Above the mined area, the Queen Gulch stream channel is small and the gradient is relatively steep (OtterTail 2012). The lower end of the stream flows over tailings, dropping approximately 8 feet onto the Crooked Creek floodplain. All the flow from the series of ponds fed by Ruby and Queen Gulches is directed into a ditch that flows parallel to Crooked Creek for 2,400 feet before its confluence with Crooked Creek.

Donlin Creek and its tributaries drain an area of 30.5 square miles. Donlin Creek joins Flat Creek to become Crooked Creek between Snow and Ruby Gulches. Donlin Creek has a moderate gradient and relatively high sinuosity, resulting in classic riffle-run-pool habitat types. Although heavy icing during winter results in some sections of the stream freezing solid, pool depth is generally sufficient to provide fish overwintering habitat, or at a minimum egg incubation for coho salmon. Gravel and cobble are the dominant substrates in riffles throughout much of the Donlin Creek mainstem.

The upstream end of Crooked Creek is at the confluence of Donlin and Flat Creeks. The Crooked Creek watershed covers 336 square miles and ranges in elevation from 135 feet to 3,610 feet, with a total basin relief of approximately 3,475 feet and a mean basin elevation of 856 feet. The main channel length is approximately 49 miles. The morphology of Crooked Creek between Anaconda Creek and the Donlin Creek-Flat Creek confluence is typical of a low gradient sinuous stream, characterized by riffle-pool channel types. Channel bed material in the steeper riffle sections is predominately coarse gravel and sand, and in the lower gradient pool sections is predominately sand and silt. The upper Crooked Creek tributaries that have been impacted by placer mining include Quartz, Snow, Lewis, Ruby, and Queen Gulches (OtterTail 2012).

Fisheries

Populations of Chinook, chum, and coho salmon as well as limited numbers of sockeye and pink salmon have been recorded in Crooked Creek. Additionally, Dolly Varden, Arctic grayling, slimy sculpin, burbot, and round whitefish are present in Crooked and Donlin Creeks. Surveys in Snow Gulch have documented the presence of Dolly Varden and occasionally adult coho salmon in the lower reaches attempting to migrate upstream. Surveys in Crooked Creek have documented presence of Chinook, coho, and chum salmon above Queen Gulch, and coho and chum salmon above Snow Gulch. In aerial surveys of the mainstems of Crooked and Donlin Creeks, over 90 percent of chum and Chinook salmon adults documented were present in the lower drainage downstream from Eagle Creek (approximately 6 miles downstream from Queen Gulch), while 67 percent of coho salmon adults documented were identified in upstream areas in the drainage, in Donlin Creek. Table 4 lists fish species present by drainage.

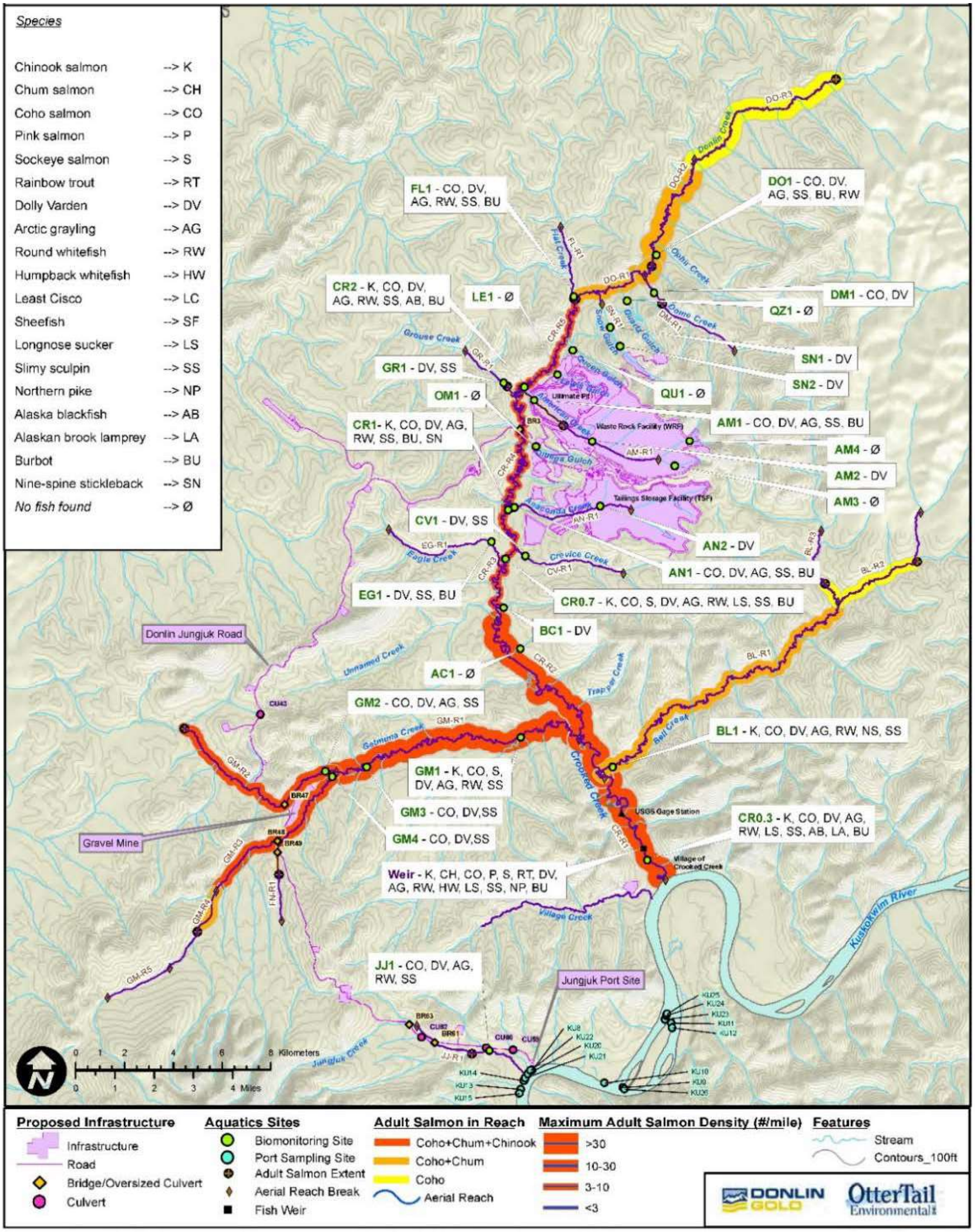
Table 4 Summary of Fish Presence 2004 — 2014

	Salmon Species					Resident Fish Species					
Drainage	**Chinook**	**Chum**	**Coho**	**Sockeye**	**Pink**	**Dolly Varden**	**Rainbow Trout**	**Arctic Grayling**	**Burbot**	**Slimy Sculpin**	**Round Whitefish**
Quartz Gulch	-	-	-	-	-	-	-	-	-	-	-
Snow Gulch	-	-	x	-	-	x	-	-	-	-	-
Ruby Gulch	-	-	-	-	-	-	-	-	-	-	-
Queen Gulch	-	-	-	-	-	-	-	-	-	-	-
Donlin Creek	-	x	x	-	-	x	-	x	x	x	x
Crooked Creek	x	x	x	x	x	x	x	x	x	x	x

Sources: ADF&G 2010; OtterTail 2012, 2014
“-“ Not Applicable.

Figure 2 shows the resident fish species present and the adult salmon densities in the Crooked Creek watershed, including in the upper Crooked Creek drainages. The section of Crooked Creek receiving input from placer mining-impacted tributaries has reduced salmon densities compared to upstream and downstream reaches. Fish surveys have also documented reduced fisheries use numbers at sampling locations downstream of Snow Gulch compared to upstream points.

Figure 2 Fish Species Present and Adult Salmon Densities in Upper Crooked Creek Drainages



Source: OtterTail Environmental, Inc 2014

OtterTail Environmental, Inc. (OtterTail) conducted habitat research and baseline fish and aquatic invertebrate sampling from 2004 through 2014 (OtterTail 2014). They found that Crooked Creek exhibited a similar composition but lower abundance of fish and invertebrate species compared to other similarly sized tributaries to the Kuskokwim River. They attributed this finding to the naturally high siltation rates and cobble embeddedness in Crooked Creek, which appeared to be higher on average than other similarly sized tributaries (OtterTail 2014). These results may be partial evidence that the long-term placer mining activity has influenced the fisheries habitat in the downstream reaches of Donlin and Crooked Creeks. Sedimentation and siltation may have degraded downstream fish habitat. Historical aerial photographs taken during active mining in the early 1950s clearly show high volumes of sediments entering the mainstem streams and suggest likely impacts to substrate gravels and siltation. Additionally, fish presence is limited in the lower reaches of the Plan area drainages due to obstacles created from previous placer mining. Alteration and degradation of floodplains have contributed to steep and unstable stream channels and narrowed hydraulic conveyances that are susceptible to beaver activity, resulting in loss of fish passage.

Soils

Crooked Creek is within the Western Interior Rivers Soil Survey Area based on Soil Survey Geographic Database mapping by the United States Department of Agriculture, Natural Resources Conservation Service (NRCS 2008). The restoration sites are underlain by two soil map units: 1) the Yukon-Kuskokwim Highlands, Boreal Floodplains, and Terraces (R30FPA); and 2) the Yukon-Kuskokwim Highlands, and Boreal and Subalpine Mountains (R30MTC). Unit R30FPA is located in the floodplain of Donlin and Crooked Creeks. Soil organic depths are typically 0 to 4 inches, composed of peat and other organic matter for boreal scrub, silty terraces. Unit R30MTC is located on the slopes east of Donlin and Crooked Creeks, including Quartz, Snow, Ruby, and Queen Gulches. Soil organic depths are typically 0 to 7 inches, composed of stratified peat to silt loam for boreal scrub, silty colluvial slopes. The dominant mineral soil texture is silt loam. Additional soils information is provided in the 2016 Preliminary Jurisdictional Determination (PJD) Report prepared for the restoration sites (Michael Baker 2016).

Vegetation Types

The disturbed areas within the Plan area are currently dominated by open willow shrub (OWS) and open alder willow shrub (OAWS) communities in wetland areas, and disturbance-related shrub and sapling re-growth (DSSR) in upland areas. OWS and OAWS communities contain limited to no tree cover and an open canopy of shrubs (25 to 74 percent cover) in which willow (*Salix* spp.) and/or alders (*Alnus* spp.) are dominant. DSSR communities contain young re-growth of tree species (e.g., birch [*Betula neoalaskana*], spruce [*Picea* spp.], aspen and balsam poplar [*Populus* spp.]) and ericaceous shrubs on previously disturbed areas. The vegetation types present in the restoration sites were described in the 2016 PJD (Michael Baker 2016).

Wetlands

Wetland mapping and descriptions of wetland types present in the Plan area were provided in the 2016 PJD (Michael Baker 2016). Table 5 shows acreages of each resource type within the four restoration areas.

Table 5 Upper Crooked Creek PRM Plan Restoration Areas Current Resource Types, by Site (Acres)

Resource Type	Area (Acres)	
Quartz Gulch Restoration Area		
Wetland	25.2	
Disturbed Wetland	8.7	
Disturbed Waterbody	0.4	
Disturbed Upland	8.5	
Upland	2.2	
Quartz Gulch Restoration Area Total		**45.2**
Snow Gulch Restoration Area		
Wetland	17.8	
Waterbody	0.9	
Disturbed Wetland	1.7	
Disturbed Waterbody	1.7	
Disturbed Upland	14.6	
Snow Gulch Restoration Area Total		**36.7**
Tailings Restoration Area		
Wetland	12.2	
Disturbed Wetland	4.9	
Disturbed Waterbody	0.7	
Disturbed Upland	7.9	
Upland	3.3	
Wash Plant Tailings Area Total		**29.3**
Ruby/Queen Gulch Restoration Area		
Wetland	56.6	
Waterbody	1.2	
Disturbed Wetland	4.7	
Disturbed Waterbody	4.7	
Disturbed Upland	31.4	
Upland	11.7	
Ruby/Queen Gulch Restoration Area Total		**110.3**
Total Area		**221.5**

Note: Inconsistencies in sums are due to rounding.

Non-native Plant Species

Not all non-native species are considered invasive and a risk to natural ecosystems. To prioritize species management tasks, Alaska Natural Heritage Program staff, in cooperation with other agencies, developed a system to summarize the risk a non-native species poses to natural habitats in Alaska as a numerical score with a corresponding invasiveness ranking (Carlson et al. 2008). A score greater than 70 is considered "Highly Invasive," indicative of a species likely to pose a serious threat to natural ecosystems in Alaska. Species with scores of 60 to 69 and 50 to 59 are considered "Moderately Invasive" and "Modestly Invasive," respectively, while those with scores between 40 and 49 are considered "Weakly Invasive," and scores below 40 are considered "Very Weakly Invasive" (Carlson *et. al.* 2008, Nawrocki *et al.* 2011).

Surveys of the Project area in 2014 found eight non-native plant species present in the vicinity of the Lyman yard and airstrip in Snow Gulch (Moody 2015, Table 6). No Highly Invasive species were found. A survey of non-native plant species presence and extent will be conducted within all of the Plan area prior to initiation of mitigation activities.

Table 6 Non-native Plant Species in Snow Gulch

Species	Invasiveness Score	Invasiveness Ranking
Matricaria discoidea (pineapple-weed)	32	Very Weakly Invasive
Stellaria media (common chickweed)	42	Weakly Invasive
Plantago major (common plantain)	44	Weakly Invasive
Poa pratensis ssp. *pratensis* (Kentucky bluegrass)	52	Modestly Invasive
Trifolium hybridum (alsike clover)	57	Modestly Invasive
Taraxacum officinale (common dandelion)	58	Modestly Invasive
Leucanthemum vulgare (oxeye daisy)	61	Moderately Invasive
Hordeum jubatum (foxtail barley)	63	Moderately Invasive

Sources: Moody 2015, Carlson *et. al.* 2008, Nawrocki *et al.* 2011

Determination of Credits

For this Plan, watershed restoration mitigation credits are measured in acres of wetland floodplain habitat and off-channel stream habitat restored and enhanced, while mitigation credits for stream restoration are measured in linear feet of stream channel restored. The Plan will produce 95.7 wetland acre credits and 8,982 linear feet of stream credits. The reshaping of the watersheds and stream channels will allow for proper hydrologic functioning and re-establishment of natural wetland floodplain habitat. Placer mining ponds will be deepened to create overwintering habitat and littoral zones will be added. Littoral zones are productive areas of aquatic ecosystems, allowing for nutrient retention and cycling of elements, shoreline and sediment stabilization, aquatic vegetation growth, refuge for juvenile fish, and organic material inputs (Peters and Lodge 2009). Table 7 shows the acreage and linear feet of re-established and enhanced aquatic resources and associated habitats. Table 1 contains the expected mitigation credits by NWI classification associated with this Plan.

Buffers around the reestablished and enhanced habitats will also be protected under the site protection instrument to maintain the long-term viability of the aquatic resource. These buffers will provide protection of the restored aquatic habitats from future disturbance, including sedimentation, and will maintain permanent connections to Crooked Creek. Buffer areas function to maintain water quality, limit sediment loads, maintain thermal processes, maintain microclimatic conditions, filter particulates and metals from remaining placer stockpiles, filter nutrients, provide organic matter inputs, maintain habitat for wildlife, and serve as corridors for wildlife movement. Buffer areas process pollutants and prevent the areas from serving as a source of pollution by slowing surface flow and allowing for infiltration before water reaches downslope wetlands and streams.

Table 7 Acreage and Linear Feet of Resources Re-established, Enhanced, and Protected by the Upper Crooked Creek PRM

	Quartz Gulch	Snow Gulch	Wash Plant Tailings Area	Ruby and Queen Gulches	Total
Re-establishment of Stream Channels to Pre-mining Conditions (Linear Feet)	1,630	4,421	-	2,931	8,982
Re-establishment of Wetland Floodplain Habitat (Acres)	13.1	21.9	11.4	49.3	95.7
Enhancement of Off-channel Pond Habitat (Acres)*	-	2.7*	0.5*	12.0*	15.2*
Enhancement of Terrestrial Habitat (Acres)	2.5	3.4	2.4	8.5	16.8
Protection of Buffer Areas (Acres)	29.5	11.4	15.6	52.5	109.0
Total Protected under Site Protection Instrument (Acres)	**45.2**	**36.7**	**29.3**	**110.3**	**221.5**

*Acreage of enhanced off-channel pond habitat is included within the re-established wetland floodplain habitat.
"-" Not Applicable.
Note: Inconsistencies in sums are due to rounding.

These acreages are further broken down, for application of mitigation credits, into aquatic resource types and HGM categories in Table 8.

Table 8 Upper Crooked Creek HGM Summary

Aquatic Resource Type	HGM	Acres
Wetland	Depressional	1.6
	Flat	32.7
	Riverine (non-anadromous)	93.0
	Riverine (anadromous)	18.0
	Slope	11.6
Stream	Riverine Channel	3.6
Upland	N/A	61.0
	Total	**221.5**

The 100-foot buffer size for this Plan was selected using guidance from the ADNR Kuskokwim Area Plan for State Lands (1988). ADNR's plan states that a 100-foot buffer on wetlands with an outlet will minimize adverse impacts on the important functions of wetlands. ADNR's information represents the best available information in this region of Alaska for protecting and maintaining the ecological functions associated with aquatic resources. Upstream of restoration areas, buffers are 100 feet, while downstream of restoration areas they are expanded to include all surface and subsurface hydrologic connections to Crooked and Donlin Creeks. The size of the buffers are reduced at Snow Gulch site due to land ownership restrictions associated with the homestead at the Lyman property. Overall, approximately 109 acres of upland and wetland buffer area (in addition to the re-established and enhanced areas) will be protected under the site protection instrument (Figure 1).

Mitigation Work Plan

Site-specific preliminary work plans have been prepared for each of the four restoration areas. These work plans are provided in the following sections. Restoration design parameters will be finalized based on detailed field surveys of the sites, which will serve as a final refinement of the restoration plans that will include timing, grading plans, overburden removal, revegetation design plans, erosion control, and dewatering, as well as stream plan/profile form and function and stream diversion plans for stream work. This design effort will address and finalize the functional hydrologic and geomorphic parameters, and serve as a basis for restoration construction management, inspection, and quality control. Final design documents shall be subject to USACE approval.

At this time, there are limited reference reach studies for the restoration sites. Much of the data collected on reference reaches are, by default, the areas upstream and downstream of the disturbed portions of these gulches. The actual mined areas proposed for mitigation are associated with the transition zones where the steep side gulches flatten out as they meet the Donlin Creek and Crooked Creek floodplains. These are where the gold placers were deposited over time and where subsequent mining caused the most disturbances. The following preliminary hydraulic and habitat functional designs for each area are proposed. These designs are based on existing information as follows:

1. High resolution aerial photography of the area, and ground surveyed topography augmented with Light Detection and Ranging (LiDAR) digital elevation mapping.

2. Stream surveys, cross sections, profiles, vegetation typing, and other field data collected by Three Parameters Plus, Inc., (3PPI) in 2013–2014 (Donlin Gold 2014).

3. Hydrologic analyses of stream flows, both of existing conditions and with potential impacts from the Project, performed by BGC Engineering. These analyses utilized surface and groundwater modeling to assess existing flows as well as USGS regression analysis of projected flood flows. The values used in these restoration designs are based on 2-year and 100-year flood flows without the potential drawdown in groundwater associated with mine development or potential attenuation effects of the planned water reservoir in the upper reaches of Snow Gulch.

4. Extensive fisheries work performed by OtterTail Environmental, Inc. from 2004 through 2014 (OtterTail 2004), and Owl Ridge Resource Consultants in 2016–2017. This work catalogued the current usage of streams in the upper Crooked Creek watershed by anadromous and resident fish populations and made site-specific recommendations for habitat restoration in the upper Crooked Creek placer mining areas. Recommendations included the reclamation habitats best suited to each drainage considering fish species most likely to benefit from the restoration.

Prior to final submittal of design documents, a more detailed stream and topographic survey of these and adjacent unmined gulches will be conducted to establish baseline reference reach parameters to guide the designs. Determination of a full suite of geomorphic measurement parameters will be made and incorporated into both the design and performance standards. These parameters will ensure the appropriateness of the design and measure the performance of the completed restoration over time.

Although reference reach information will help guide the design process, some of the proposed restoration work involves creation of significant ponded features that are not natural features of this watershed. As such, these features will rely more heavily on the experience of fisheries, wetland, and stream reconstruction specialists. Enhancement of fisheries habitat is the design goal of these non-stream enhancements.

Restoration Timing

Construction of the four restoration projects is planned to occur over four consecutive years, with the potential for some to occur simultaneously. Work at each restoration area will require one construction season. A general schedule for a restoration area is shown in Table 9.

The restoration areas will be revegetated promptly after completion of earth-disturbing activities to reduce the potential for erosion, sedimentation, and invasive species colonization. Revegetation will be conducted no later than the beginning of the first growing season after construction is completed. Revegetation activities will be performed in accordance with the final revegetation design plan, which will identify targeted vegetation communities for each revegetation area. The final revegetation design plan will be part of the final design package and will be provided to USACE prior to implementation.

Revegetation will be conducted using guidance from the Interior Alaska Revegetation and Erosion Control Guide (Czapla and Wright 2012) and the Streambank Revegetation and Protection Guide (ADF&G 2005). Methods and techniques will be determined by site conditions, including soils, hydrography, slope, and aspect, but may include seeding grasses, planting willow cuttings or other shrubs, spreading charged overburden, and allowing natural re-colonization. Mulches, topsoil, and fertilizer will be placed as conditions warrant. Certified weed-free seed mixes will be used.

Table 9 Typical Construction Schedule for a Restoration Area

Season	Activity
Year 1	
Summer	Conduct stream channel work during this low-flow period. Reshaping of floodplains, regrading of tailings areas, filling of ditches, and pond construction activities may also occur in late summer.
Fall and Winter	Conduct continued reshaping of floodplains, regrading of tailings areas, filling of ditches, and pond construction activities, which may occur in wet or flooded areas.
Year 2	
Spring	Conduct post-construction survey after break-up; plant willow cuttings to stabilize stream banks.
Early Summer	Perform revegetation activities.
Winter	Submit design criteria monitoring report.
Years 3-6	
Summer	Conduct monitoring activities; perform any required management activities to ensure performance standards are met.
Winter	Submit monitoring report.
Year 7	
Summer	Conduct monitoring activities.
Winter	Submit final monitoring report and monitoring closeout report (for entire Plan area assuming performance standards are met).

Quartz Gulch

Quartz Gulch Existing Conditions

Historical placer mining in Quartz Gulch has left a heavily impacted, but partially revegetated, stream valley (Appendix D-1, Figure 2). The gulch bottom was stripped of vegetation and mined, and spoils piles were pushed to the sides of the valley floor. Some of these disturbed areas have had significant time to revegetate. Much of the lower portion of the gulch has been re-contoured, leaving a series of ditches, spoils piles, and an impacted stream channel. At the upper end of the previously mined area, the gulch and stream channel have been cut with a cross ditch that collects groundwater and surface waters and re-directs flow along the west side of the gulch for approximately 1,100 linear feet. In the existing condition, this lateral ditch leaks water downslope, and fish passage can be blocked during low flow periods. In its present location, the stream is above the water table and loses flow to groundwater, a significant loss during low flow conditions.

Although the main course of the stream follows the mining ditch along the west side of the gulch, a secondary stream has re-established in the bottom of the valley, fed by surface water from the east side of the watershed as well as groundwater seepage from the perched mining ditch on the west side of the gulch. Historical aerial photographs show the original stream followed the path of the secondary stream fairly closely in the upper portion of the gulch. Lower in the gulch, the ditch discharges back to the valley floor and follows the original valley bottom in a less confined channel, through what appears to be an adequate and substantially revegetated floodplain. Where the stream enters the Donlin Creek floodplain, it has created a small back water stream along the mainstem. The stream eventually enters a second, long diversion ditch that bypasses a section of the Donlin Creek floodplain, including an abandoned oxbow, and discharges to Donlin Creek approximately 900 feet downstream. This ditch lowers the water table in the bypassed portion of the Donlin Creek floodplain and creates a potential bypass risk for the mainstem of Donlin Creek. A mainstem bypass of this type would result in substantial loss of natural aquatic habitat.

Existing conditions in Quartz Gulch are depicted in Appendix D-1, Figure 2.

Quartz Gulch Restoration

The proposed restoration activities include filling the diversion ditch features in Quartz Gulch and the Donlin Creek floodplain, directing the flows in the upper portion of Quartz Gulch to the secondary stream channel along the original stream path, and allowing the backwatered flows to return to Donlin Creek via the abandoned oxbow in the lower end of the system. Elimination of the mining ditch in the upper portion of the gulch will re-establish the historical channel along the valley floor. This movement of the main channel should return the stream to a more stable hydrologic regime and remove the hydraulically losing reach from the system. The removal of both ditch sections will result in expanded floodplain overbank flow function for the re-established stream sections in Quartz Gulch and Donlin Creek.

A preliminary estimate of the stream restoration parameters for Quartz Gulch is included in Table 10. As the engineering design progresses, further refinements will be made based on reference reach parameters where available, or Rosgen and regional functional parameters for drainages with similar watershed characteristics.

Table 10 Preliminary Design Parameters for Quartz Gulch

Parameter	Preliminary Design Value
Basin Area	1.18 square miles
Stream Type (Rosgen)	G3
Q2	22.8 cubic feet/second, 3.9 feet/second
Q100	125 cubic feet/second, 3.6 feet/second
Valley Slope (average)	Less than 5%
Channel Slopes	Upper Reach 4.7% Mid Reach Step 16% Lower Reach 2.8%
Bank Full Width	7–12 feet
Ordinary High Water Width	3–8 feet
Floodplain Width	35–70 feet (narrower in steeper sections)
Bank Height Ratio (BHR)	Less than 1.2
Entrenchment Ratio (ER)	Greater than 3
Width:Depth Ratio	Stable
Profile Form	Riffle-Pool or Riffle-Run-Pool Step Pools (step section)
Sinuosity	1.35; straighter in steeper sections
Belt Width	20-25 feet
Channel Depth	1.0 foot in riffles 1.8 feet in pools
Riffle Spacing	+/- 20 feet
Grade Control	Large wood debris, roots of bank vegetation, larger rock substrate

Subject to final design refinement, the following work plan sequence is proposed for Quartz Gulch. Appendix D-1, Figure 3 illustrates the components of this work plan. Appendix D-1, Figure 4 illustrates the proposed outcome of the restoration. The work plan includes:

1. Backfill diversion ditch in the Donlin Creek floodplain, utilizing the side cast spoils pile left from the original excavation. Return the ground contours to elevations consistent with the surrounding floodplain and revegetate this area with native species per the revegetation design plan. This work will increase surface and groundwater elevations in the surrounding floodplain, divert Quartz Gulch flows back to Donlin Creek via the abandoned oxbow upstream of the ditch, restore natural hydrology allowing for natural re-establishment of wetlands, and provide a settlement area for runoff from any subsequent restoration work further upstream in Quartz Gulch.

2. Survey the historical stream channel area in the upper gulch to determine if this channel contains the necessary hydraulic form and habitat functional components for re-watering. This channel will be assessed based on the finalized design parameters. Any augmentation of this existing channel will be carried out prior to re-watering. It is anticipated that work in this area will be minimally

invasive to preserve the revegetated portions of the mined areas as much as possible. Appendix D-2, Sheets 1 and 2 show the preliminary cross section and profile of the restored stream channel.

3. Refill the cross gulch and lateral slope ditch with existing onsite spoils, and return the full flow to the gulch floor channel. Filling the ditch will return pre-mining ground and surface flows to a sustainable and more habitat-diverse channel in the valley floor. This is also expected to increase flows in the rerouted section across a wide range of hydraulic conditions, especially during low and winter flow conditions.

Table 11 is a summary of the Quartz Gulch Restoration Area restoration activities.

Table 11 Summary of Re-established, Enhanced, and Protected Areas within the Quartz Gulch Restoration Area

Restoration Activity	Habitat Type	Linear Feet	Acres
Re-establish	Stream channels	1,630	-
Re-establish	Floodplain habitat	-	9.7
Re-establish	Floodplain habitat (includes revegetation)	-	3.4
Enhance	Terrestrial habitat (includes revegetation)	-	2.5
Protect	Buffer	-	29.5
	Total	**1,630**	**45.2***

*Entire area will be covered under the site protection instrument.
"-" Not Applicable.

The results of these proposed hydraulic and geomorphic functional restorations on the fisheries resources are as follows:

- An increase in rearing habitats for resident fish and coho salmon juveniles in the lower reaches of Quartz Gulch, and the adjacent Donlin Creek floodplain and oxbow.
- Improved low water and slightly improved winter flows within Quartz Gulch, improving summer rearing opportunities and year-round resident fish habitat.
- Better temperature regimes for resident and rearing fisheries populations resulting from the replacement of ditched flows with more natural and better shaded valley floor stream channels.
- Long-term reduction in substrate embeddedness and potential spawning habitat improvements in Crooked Creek through improved water quality and reductions of suspended solids in Quartz Gulch and downstream reaches of Donlin Creek, especially at higher flows.

Snow Gulch

Snow Gulch Existing Conditions

Lower Snow Gulch has been impacted by disturbance that began in 1910 and continued through 2016. Mining has resulted in several changes that have impacted the aquatic resources, both in Snow Gulch and the adjacent Donlin Creek floodplain. In addition to the release of large quantities of suspended sediments into the watershed, as evidenced by historical imagery, placer mining activities have left three areas of excavated ponds (upper, middle, and lower) connected by the stream, which has been diverted and channelized in several areas. The remnant stream, ponds, and valley bottom exhibit steep unstable side slopes, filled wetland areas, unsustainable stream channel gradients, little or no floodplains, disconnected groundwater and surface waters, and denuded erosional features that occasionally contribute sediment during high flow events.

The primary obstacle to overcome at this site is that the excavated ponds have created flat sections in the post-placer mining valley stream profile, resulting in an unnaturally steep gradient for the remaining portions of the stream profile. The pre-mining valley slope is approximately 2 percent from above the upper pond to the outfall into the lowest excavation pond. Portions of the existing channelized stream slope approach 10 percent. A second challenge is the lack of any significant overbank floodplain along the current excavated stream channel. The resultant steepened and confined channel exhibits high velocity scour from flood flows, which results in unstable banks and suspended sediment, especially during high flow events.

Existing conditions in Snow Gulch are depicted in Appendix D-1, Figure 5.

Snow Gulch Restoration

Restoration of Snow Gulch will involve restoration of a sustainable stream channel as well as restoration and revegetation of the floodplain in the lower gulch, modification of the excavated ponds to create shallow and deep water (greater than 6 feet) aquatic habitats, and re-connection of groundwater and surface waters to the Donlin Creek floodplain.

To restore this stream system, a new channel will be constructed between the lower and middle ponds from the substrate materials that originally formed the historical channel. The new channel will exhibit scour and sediment transport properties consistent with the original sediments, geometry, gradients, and resultant flood flow velocities. The new channel will be designed to mimic the parameters of the pre-mining system based on calculations from undisturbed sections of Snow Gulch and from analysis of flood flow hydraulics. Portions of the regionally rare and productive habitat provided by the middle ponds will be retained.

In Snow Gulch, the upper and middle excavated ponds will be enhanced to create additional fish and quiescent water habitat. A portion of the northern end of the middle pond will be filled to gain additional length for the proposed re-constructed channel. Additional length is needed for the created channel to approach the gradient parameter of the original system in the sections that are now flat open water ponds. A sinuous channel routing will be chosen to minimize cut and fill requirements, following a detailed survey of the area prior to construction. Stream channel substrate will be locally available fill materials with sufficient fines (greater than 20 percent) to sustain surface flows, and may be augmented with larger rock and woody debris features as needed to provide aquatic invertebrate substrate, hydraulic cover, low flow channelization for fish, and grade control to maintain channel stability.

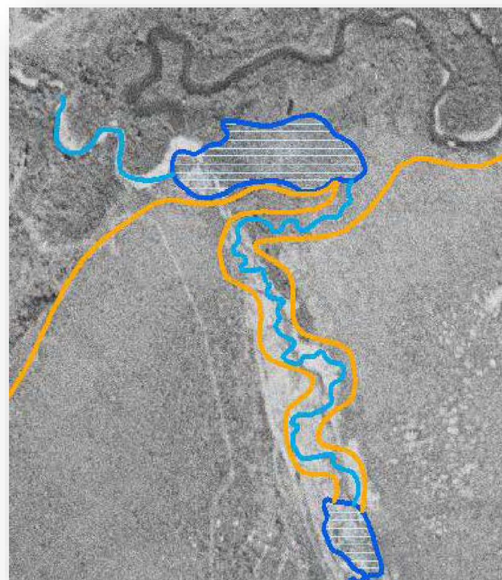
A fish passage conveyance may be required on at least one access route linking the Lyman airstrip, which runs along the east side of Snow Gulch, with the facilities on the southwest side of the middle pond. If the structure is located in the backwater between the middle ponds, a simple, large diameter, round culvert will be sufficient. If this structure is located along the stream channel, the final design will contain provisions for a stream simulation designed conveyance with width equal to 120 percent of the stream bank full width.

The historical connection from Snow Gulch to Donlin Creek is currently blocked by a berm on the west side of the lower pond. The historical channel feature, while difficult to see from current aerials, shows up prominently in black and white aerial photographs from 1953 (Figure 3). To re-establish the connection with the Donlin Creek floodplain, the berm surrounding the west and north ends of the lowest pond will be removed and the current connection from the pond to Donlin Creek will be filled. Removal of the berm will funnel stream flow back into the historical channel west of the pond, and re-water off-channel habitat. The lower pond will be excavated and provide additional settlement area to improve downstream water quality.

Figure 3 Comparison of Recent and Historical Aerial Imagery for Snow Gulch Outlet to Donlin Creek

2016 Aerial Photography

1953 Aerial Photography
(USGS EarthExplorer)



Note: Post-construction stream channel and ponds shown on both images.

A portion of the historical connection between the lower pond and Donlin Creek will have to be re-excavated to remove placer tailings, but the remaining oxbow channel will be re-watered in its present condition. Reintroduced stream flows are expected to reform a small thalweg within the oversized and vegetated channel. These historical channels are typically incised less than 1.5 to 3 feet into the surrounding floodplain, which makes it difficult for beavers to completely block fish passage. Inclusion of historical channels in the completed channel design should protect the system from blockage by beavers, a problem that currently exists in the narrow, deeply incised ditch exiting the middle and lower ponds. The pond margins themselves will be returned to an elevation approximately equal to the surrounding floodplain, making blockage of fish passage by beaver dams difficult. It is assumed that the original floodplain vegetated mat will be encountered as the placer mining tailings are removed, which will both serve as a vertical indicator for excavation and provide substrate for the revegetation efforts.

A short section of the existing berm will be retained on the east side of the lower pond to prevent Donlin Creek from meandering through the pond at flood flows. Once established as a semi-natural feature, the pond will be allowed to return to the natural morphology of the surrounding floodplain and will not be artificially maintained.

A preliminary estimate of the stream restoration parameters for Snow Gulch is included in Table 12. As the engineering design progresses, further refinements will be made based on reference reach parameters where available, or Rosgen and regional functional parameters for drainages with similar watershed characteristics.

Table 12 Historical and Preliminary Design Parameters for Snow Gulch

Parameter	Historical (Pre-Mining) Value	Preliminary Design Value
Basin Area (Square Miles)	3.41	3.41
Stream Type (Rosgen)	G3	G3
100-year Flood Flow Q100 (Cubic Feet/Second)	271	271
100-year Flood Velocity (Feet/Second), Floodplain	N/A	4.0
2-year Flood Flows Q2 (Cubic Feet/Second)	55	55
2-year Flood Velocity (Feet/Second), Bank Full	N/A	4.0
Valley Slope (Percent)	Upstream of upper pond: 3.8* Lower gulch: 1.7**	1.7%
Channel Slope	Less than 2%	Less than 2%
Bank Full Width (Feet)	Upper gulch: 7 feet* Below middle pond: 20 feet	16 feet
Ordinary High Water Width (Feet)	Upper gulch: 5 feet* Existing ditch below middle pond: 8 feet	12 feet with low flow channel
Floodplain Width (Feet)	100 feet**	86-foot minimum
Bank Height Ratio		Less than 1.2
Entrenchment Ratio		Greater than 3
Width:Depth Ratio	Stable	Stable
Stream Substrate Sizing for 2-year In-channel and 100-year Floodplain Stability	N/A	D100 = 6 inches D85 = 4 inches D50 = 2 inches D30 = ½ inch D15 = #10 sand
Profile Form	N/A	Riffle-Run-Pool
Sinuosity	1.19* 1.33**	1.33
Belt Width	50	50
Channel Depth	N/A	1.0 foot in riffles 1.8 feet in pools
Riffle Spacing	N/A	+/- 20 feet
Grade Control	N/A	Large wood debris, roots of bank vegetation, larger rock substrate

*Historical values determined by 3PPI (Donlin Gold, LLC 2014).
**Historical values determined using LiDAR
N/A - Not Available.

Subject to final design refinement, the following work plan sequence is proposed for Snow Gulch. Appendix D-1, Figure 6 illustrates the components of this work plan. Appendix D-1, Figure 7 illustrates the proposed outcome of restoration. The work plan includes:

1. Remove overburden piles from Donlin Creek floodplain, reshape lower pond, and move pond outfall to historical channel west of the lower pond. The abandoned oxbow will be reutilized as the connection to Donlin Creek, mimicking the original hydraulic configuration of the floodplain prior to mining. It is anticipated that no disturbance will be required in the area of the old oxbow and that the historical floodplain vegetated mat will be uncovered by the removal of overburden. Excess overburden materials and side cast will be stockpiled or used to shape the new gulch stream channel, as required. All disturbed areas will be revegetated with native upland and wetland species.

2. The northern third of the middle ponds will be filled to create added stream channel length needed to overcome gradient constraints. A new stream channel at the proposed gradient and geometry will be constructed to join the middle ponds with the lower pond. Construction will be to the parameters of the final design. Materials will be selected from available overburden piles, with larger rock components imported from the wash plant tailings area or from Donlin Gold mining activities. Stream diversion and dewatering/re-watering of the existing and proposed channel will be per the stream diversion/dewatering plan prepared with the final design. Reshaping work within the ponds will be facilitated by cordoning off active work areas from stream flow with silt fence separators. Appendix D-2, Sheets 9 through 12 show the preliminary plan, profile and design details of the stream channel. Appendix D-1, Figure 7 shows the location of a selected cross-section. Appendix D-2, Sheet 11 shows a profile of the proposed stream alignment.

3. The outlet of the upper pond will be reinforced with larger rock to maintain the grade of this feature in perpetuity. This material will be a mixture of coarser rock components having a D50 of 6 inches, combined with finer materials to create an armored stream substrate. Areas of the middle and upper ponds will be reshaped and/or excavated to create open water diversity, with shallow and deeper water aquatic habitats. Disturbed areas will be revegetated.

Table 13 is a summary of the Snow Gulch Restoration Area restoration activities.

Table 13 Summary of Re-established, Enhanced, and Protected Areas within the Snow Gulch Restoration Area

Restoration Activity	Habitat Type	Linear Feet	Acres
Re-establish	Stream channels	4,421	-
Re-establish	Floodplain habitat	-	18.5
Re-establish	Floodplain habitat (includes revegetation)	-	3.4
Enhance	Off-channel pond habitat*	-	2.7*
Enhance	Terrestrial habitat (includes revegetation)	-	3.4
Protect	Buffer	-	11.4
Total			**36.7****

* Enhanced off-channel pond habitat is within the re-established floodplain habitat.
**Entire area will be covered under the site protection instrument. An additional 617 linear feet of stream channel, 6 acres of floodplain habitat, and 2.7 acres of off-channel pond habitat will be restored, but will not be covered under the site protection instrument because long-term protection cannot be fully ensured within the Lyman homestead area.
"-" Not Applicable.

The results of these proposed hydraulic and geomorphic functional restorations on the fisheries resources are as follows:

- Significant increase in productive pond habitats in the lower reaches of Snow Gulch, and in accessible habitat throughout Donlin Creek.
- Removal of opportunities for beaver dam blockages in channelized sections of streams, and at the narrow outfall from the lower pond to Donlin Creek.
- Increased fish passage to habitats upstream of the restoration area.
- Lowered gradient access to the middle ponds for enhanced rearing, and possibly coho spawning, habitat along this reach.
- An increase in off-channel rearing habitats for resident fish and coho salmon juveniles in the lower reaches of Snow Gulch and the adjacent Donlin Creek floodplain and oxbow.
- Raised water levels in the lower pond for improved deep water and potential overwintering habitats.
- Provision of littoral habitats in the lower pond and attendant increases in aquatic vegetation, aquatic invertebrates, water quality, and habitat diversity.
- Reduced side slopes and improved vegetative cover for improved water quality to provide additional shading and cover for fish along stream and pond margins.
- Better temperature regimes for resident and anadromous fish species resulting from the replacement of ditched flows with more natural and better shaded stream channels.
- Long-term reduction in substrate embeddedness and potential spawning habitat improvements in Crooked Creek through improved water quality via reductions of suspended solids in Snow Gulch and downstream reaches of Donlin Creek, especially at higher flows.

Wash Plant Tailings Area

Wash Plant Tailings Area Existing Conditions

Placer gravels were historically processed at a wash plant in an area between Snow and Ruby Gulches. The outlet of the wash plant was allowed to discharge to the Crooked Creek floodplain just downstream of the confluence of Donlin and Flat Creeks, with separate stockpile areas for coarse- and fine-grained materials. Coarse-grained tailings were stockpiled mostly in uplands immediately adjacent to the Crooked Creek floodplain, while fine-grained tailings were discharged into wetlands adjacent to and within the Crooked Creek floodplain, forming an alluvial fan-type deposit. In historical wetland areas at the lowest elevations of the fan, hydrophytic vegetation has re-established in the fine-grained materials. An artificial berm designed to dike off the settlement area from the mainstem of Crooked Creek remains in place and raises backwater levels in this area.

Off-channel habitats appear to have been minimally impacted by the wash plant effluent. Historical aerials show little connected open water areas.

Existing conditions at the Wash Plant Tailings Area are depicted in Appendix D-1, Figure 8.

Wash Plant Tailings Area Restoration

The Crooked Creek floodplain under the effluent discharge fan will be reshaped and re-contoured into a condition to restore wetlands back to the area. Materials will be removed down to the underlying organic layers that mark the original vertical extent of the floodplain. The berm along the settlement area will be left to maintain water levels in the restored areas. The coarse-grained tailings pile and other areas will be regraded and re-contoured for stability (minimum 2:1 slopes), and augmented with finer materials to promote vegetation growth. Disturbed areas will be revegetated.

Subject to final design refinement, the following work plan sequence is proposed for the Wash Plant Tailings Area. Appendix D-1, Figure 9 illustrates the components of this work plan. Appendix D-1, Figure 10 illustrates the proposed outcome of restoration. The work plan includes:

1. The coarse-grained tailings pile will be re-contoured and topped with fine-grained materials to promote slope stability and vegetation establishment. The coarse-grained tailings pile can be re-contoured at any time as it is mostly an uplands feature. It may be most expedient to do this work prior to the removal of fine-grained material as this material will be needed to cover the coarse-grained material and provide a growth medium for revegetation.

2. Fine-grained material covering wetlands in the Crooked Creek floodplain will be excavated in winter, and the area will be revegetated with herbaceous hydrophytes. Removed material will be utilized at the coarse-grained tailings pile and at other places in the restoration to facilitate development of hydric soils and growth of hydrophytic vegetation.

Table 14 is a summary of the Wash Plant Tailings Area restoration activities.

Table 14 Summary of Re-established, Enhanced, and Protected Areas within the Wash Plant Tailings Area Restoration Area

Restoration Activity	Habitat Type	Acres
Re-establish	Floodplain habitat (includes revegetation)	10.8
Enhance	Off-channel pond habitat*	0.5*
Enhance	Terrestrial habitat (includes revegetation)	2.4
Protect	Buffer	15.6
	Total	**29.3****

* Enhanced off-channel pond habitat is within the re-established floodplain habitat.
** Entire area will be covered under the site protection instrument.

The results of these proposed hydraulic and geomorphic functional restorations on the fisheries resources are as follows:

- Fisheries improvements from these restorations are related to reductions in suspended solids entering the mainstem of Crooked Creek. This will positively impact spawning area and smolt production.
- Some pond habitats will be produced and/or maintained in the re-established floodplain.

Ruby and Queen Gulches

Ruby and Queen Gulches Existing Conditions

The most downstream disturbance in the Plan area is at Ruby and Queen Gulches, where significant areas of excavation, overburden deposition, and dewatering ditches have altered the landscape and impacted hydraulic function.

The lower 800 feet of Ruby and Queen Gulches have been mined extensively. Ruby Gulch has been mined more recently. There is a 3-foot head cut at the upper end of Ruby Gulch where the original stream channel spills out of a forested area into the placer mining scar. Removal of the floodplain, riparian habitat, and stream channel have left a wide, poorly contained channel running on a mostly bedrock substrate. Areas of steeper slopes and unconsolidated and unvegetated substrate result in ongoing erosion and siltation of the downstream during high flow events.

In Queen Gulch, the majority of the stream flow is routed from the historical channel into a mining ditch along the south side of the gulch for approximately 500 feet. Lower in the gulch the stream flows through two excavated ponds and under a mining access road before flowing into a long diversion ditch in the Crooked Creek floodplain. Considerable time has elapsed since Queen Gulch was mined and areas of the lower gulch have revegetated.

Once in the Crooked Creek floodplain, Ruby and Queen Gulch empty into a series of large excavated ponds and ditches. Ruby Gulch provides water at the north end of this system where it flows into the northern-most pond. A small unnamed drainage enters the system between Ruby and Queen Gulches, and at the south end of the system Queen Gulch enters from the east just below the “square pond.” Groundwater from the adjacent hill slope also feeds into the system throughout its length.

This system is below the elevation of the floodplain of Crooked Creek, lowering the water table, degrading aquatic habitat and restricting fish access. Steep sided back and subsurface pond slopes are unstable, contributing to sediment and erosion, especially during high flow conditions. Overburden stockpiles in the Crooked Creek floodplain block surface and groundwater flows into Crooked Creek and impact adjacent wetland areas. Narrow hydraulic conveyances between ponded areas contribute to fish passage blockage by beaver activities. South of the square pond, the system flows into a long ditch that parallels Crooked Creek for 2,400 feet. This ditch both lowers the elevations of the water in the ponds below the Crooked Creek floodplain and intercepts groundwater from the hillsides east of the creek. Steep sides along the ditch contribute to erosion and degraded water quality. The ditch lowers the water table and separates upslope groundwater and surface water flows from the Crooked Creek floodplain. Side cast overburden along the ditch degrades adjacent wetlands.

Existing conditions in Ruby and Queen Gulches are depicted in Appendix D-1, Figure 11.

Ruby and Queen Gulches Restoration

Restoration activities for Ruby and Queen Gulches will include restoring portions of the Ruby Gulch stream channel, removing overburden stockpiles in the Crooked Creek floodplain, filling the drainage ditch in upper Queen Gulch to reroute the stream to the valley floor, reshaping the ponds to provide increased shallow water and deep water habitats, removing constricted areas where beaver activity can easily block fish passage, restoring a floodplain elevation outlet from the ponded area through abandoned oxbows into Crooked Creek, and filling in the long drainage ditch currently connecting the ponded area to Crooked Creek. Disturbed areas will be re-contoured into shallow slopes running down to the ponds, allowing re-establishment of the floodplain and diverse aquatic habitats. Disturbed areas will be revegetated.

Restoration of Ruby Gulch will be similar to that of Snow Gulch except on a smaller scale. Re-establishing the historical floodplain gradient will involve refilling the area with appropriate substrate, shaping an appropriately sized channel, adding habitat features and grade control, and revegetating disturbed areas. Fish passage structures may be required where Ruby and Queen Gulches are crossed by the existing mining access road.

Reconnection of Ruby and Queen Gulches to the Crooked Creek floodplain is more complex than at Snow Gulch. The pond system fed by the gulches is separated from the Crooked Creek floodplain by a steep-sided berm constructed from the overburden materials removed from placer mining operations. North of the dogleg at the north end of the berm is a large deposit of overburden tailings that will be left substantially intact to prevent the main Crooked Creek channel from shortcutting through the ponds. At the dogleg, additional water is added to the system from a shallow, surface water basin and the tailings deposit is reduced to a simple berm separating the ponds from the floodplain. This berm would be substantially removed south of the dogleg so the pond features would be joined hydraulically with the existing natural oxbows along Crooked Creek. The average elevation of these oxbows (382 feet) appears consistent with the proposed water level in the ponds.

Restoration of Queen Gulch has been developed while considering the predicted drawdown effects from the proposed open pit. Rerouting of flow in Queen Gulch will be similar to Quartz Gulch with available side cast used to refill the ditch, rerouting the flows to the old stream channel location and revegetation of disturbed areas. Expansion of two small ponded areas in the lower reach will enhance resident fisheries habitats. The flows from Queen Gulch will be re-directed into the square pond. A fish passage conveyance or low water ford will be provided at the road crossing. Berms around the south and west sides of the square pond will be removed to re-connect this pond with the floodplain and the pond margins will be regraded similar to the more northern ponds. An outfall will be established to an existing oxbow in the northwest corner of the square pond.

Finally, the ditches connecting the northern ponds to the square pond and the diversion ditch, which connects the pond system to Crooked Creek, will be refilled with the side-cast materials and revegetated.

A preliminary estimate of the stream restoration parameters for Ruby Gulch is included in Table 15. As the engineering design progresses, further refinements will be made based on reference reach parameters where available, or Rosgen and regional functional parameters for drainages with similar watershed characteristics.

Table 15 Historical and Preliminary Design Parameters for Ruby Gulch

Parameter	Historical (Pre-Mining) Value	Preliminary Design Value
Basin Area (square miles)	0.34	0.34
Stream Type (Rosgen)	G3	G3
100-year Flood Flow (Cubic Feet/Second)	50	50
100-Year Flood Velocity (Feet/Second)	N/A	3.5
2-Year Flood Flows Q2 (Cubic Feet/Second)	8	8
2-Year Flood Velocity (Feet/Second), Bank Full	N/A	3.3
Valley Slope	Less than 5%	Less than 5%
Channel Slope (Percent)	4.17	4.19
Ordinary High Water Width (Feet)	2.4	6
Bank Full Width (Feet)	9	10
Floodplain Width (Feet)	82	50
Stream Substrate Sizing for 2-year In- Channel and 100-year Floodplain Stability	Soil gradation needed	D100 = 4 inches D85 = 3 inches D50 = 1 inches D30 = 0.4 inches D15 = #10 sand
Bank Height Ratio (BHR)		
Entrenchment ratio (ER)		
Width:depth Ratio	Stable	Stable
Profile Form	N/A	Step-Pool
Sinuosity	1.16*	1.16
Belt Width	30	30
Channel Depth	N/A	1.0 foot in riffles 1.8 in pools
Riffle Spacing	N/A	+/- 20 feet
Grade Control	N/A	Large wood debris, roots of bank vegetation, larger rock substrate

*Historical values determined by 3PPI (Donlin Gold, LLC 2014).
N/A – Not Available.

Subject to final design refinement, the following work plan sequence is proposed for Ruby and Queen Gulches. Appendix D-1, Figure 12 illustrates the components of this work plan. Appendix D-1, Figure 13 illustrates the proposed outcome of restoration. The work plan includes:

1. Reshape the excavated ponds in the Crooked Creek floodplain to create shallow and deep water habitat areas. This would be done while the water table is still artificially depressed by the drainage ditch.
2. Remove the overburden berms around the south and west sides of the square pond and along the west sides of the northern ponds to the point where the berm transitions to a larger overburden deposit at the dogleg. Breach the square pond in the northwest corner and connect the other excavated areas to the abandoned oxbows to the west. Appendix D-2, Sheet 13 shows a typical section through this area.

3. Fill the mining ditch in upper Queen Gulch and re-establish the stream within the historical channel. Re-contour excavated ponds to provide enhanced off-channel habitat. Reroute the Queen Gulch stream channel in its lower section and install a fish passage structure under the existing road (or create a low water crossing) to connect Queen Gulch to the square pond.
4. Re-build the lower section of Ruby Gulch to hydraulic functional parameters as refined in final design. Add a fish passage conveyance at the mining access road as needed. Appendix D-2, Sheet 12 shows the preliminary design section of the stream channel.
5. Fill the drainage ditch extending south to Crooked Creek to restore floodplain water levels and groundwater continuity. Appendix D-2, Sheet 14 shows a typical section of this ditch fill.
6. Revegetate all disturbed areas per the revegetation design plan.

Table 16 is a summary of the Queen and Ruby Gulches Restoration Area restoration.

Table 16 Summary of Re-established, Enhanced, and Protected Areas within the Queen and Ruby Gulches Restoration Area

Restoration Activity	Habitat Type	Linear Feet	Acres
Re-establish	Stream channels	2,931	-
Re-establish	Floodplain habitat	-	46.7
Re-establish	Floodplain habitat (included revegetation)	-	2.6
Enhance	Off-channel pond habitat*	-	12.0*
Enhance	Terrestrial habitat (includes revegetation)	-	8.5
Protect	Buffer	-	52.5
	Total	**2,931**	**110.3****

* Enhanced off-channel pond habitat is within the re-established floodplain habitat.
**Entire area will be covered under the site protection instrument.
"-" Not Applicable.

The results of these proposed hydraulic and geomorphic functional restorations on the fisheries resources are as follows:

- Significant increase in productive pond habitats in the lower reaches of Ruby and Queen Gulches and in accessible habitat throughout Crooked Creek.
- Removal of opportunities for beaver dam blockages in areas of narrow conveyance, including ditches and pond inlets and outlets, which create a blockage to fish passage.
- Lowered gradient access to the lower reaches of Ruby Gulch for enhanced resident fish and juvenile coho passage and habitats along this reach.
- An increase in off-channel rearing habitats for resident fish and coho salmon juveniles in the Crooked Creek floodplain and oxbow.
- Raised water levels in the ponds for improved deep water and potential overwintering habitats.
- Provision of littoral habitats in the ponds and attendant increases in aquatic vegetation, aquatic invertebrates, water quality, and habitat diversity.
- Reduced side slopes and improved vegetative cover to improve water quality and provide additional shading and cover for fish along stream and pond margins.

- Better temperature regimes for resident and anadromous fish species resulting from the replacement of ditched flows with more natural and better shaded stream channels.
- Long-term reduction in substrate embeddedness and potential spawning habitat improvements in Crooked Creek through improved water quality and reductions of suspended solids in Queen and Ruby Gulches, especially at higher flows.

Final Design, Monitoring, and Performance Standards

Final Design

Establishing and implementing the final design, which will provide the basis for the final performance standards for the PRM, is expected to be a multi-step process, as follows:

1. Donlin Gold will perform additional field work to assess and determine the final reference reach and design parameters. In using a reference reach, Donlin Gold will be able to compare to other streams being sampled, whereby “success” will be measured as the new stream reaches fall within the natural variability of other sample sites in the monitoring program.
2. At least 6 months prior to initiating Project construction, Donlin Gold will submit to USACE a final restoration design (modifying the plans contained herein as appropriate) based on specific hydrologic, hydraulic, geomorphic, revegetation, and construction sequencing parameters.
3. USACE will approve the final design, and the final performance standards, prior to the start of Project construction.
4. Donlin Gold will construct the proposed PRM as designed and provide as-built documentation to verify that the restorations meet the design specifications.

After the completion of the constructed restoration and acceptance of the as-builts by USACE, the PRM will enter the monitoring phase to demonstrate compliance with the performance standards.

Monitoring Program

Project monitoring will be conducted to demonstrate that the PRM is meeting its performance standards, provide a basis for USACE acceptance of the work, determine if adaptive management actions are necessary, and document the aquatic resource health of the area. Donlin Gold will monitor to gauge progress against the performance standards for stream channels, wetlands, terrestrial vegetation, and fish use. Additionally, Donlin Gold will also monitor stream flow. The types of monitoring to be performed are described below. A more detailed monitoring program with locations and protocols will be submitted to USACE for review and approval, along with the final performance standards, at least 6 months prior to the start of the Project construction.

Stream Channel Monitoring

Monitoring of physical stream channel (hydraulic and geomorphic) parameters will be conducted annually for at least 5 years after construction or longer if performance standards are not met. Monitoring will take place during the same time period each year in early June, timed to coincide after spring breakup flows and before the mid-summer low water period. Obvious failures of the channel design or excessive erosion will be addressed with USACE (in coordination with ADF&G), and corrective actions will be developed by Donlin Gold and approved by USACE prior to initiation of in-stream work. If site conditions fail to meet performance standards during monitoring, the design and mitigation work plan will be reviewed and adjusted to implement solutions. After the fifth year, monitoring would only continue to be performed in those specific areas where the performance standards are not being met.

Biological monitoring of the stream channels and near pond outlets for macroinvertebrates and periphyton communities will also be conducted annually for at least five years after construction or longer if performance standards are not met. Monitoring will be conducted in mid- to late July to maintain consistency with baseline sampling and capture the period of peak abundance and species diversity.

Aquatic invertebrate sampling will be conducted using the methods Donlin Gold followed for baseline data collection. Five replicate samples will be collected to reduce sampling variability within a single site and to increase statistical power. Samples will be collected each year from the same riffle(s) using a Surber sampler (1 ft^2, 600 µm mesh). The Surber sampler will be placed on the stream bottom with its opening perpendicular to stream flow. Substrates within the 1 ft^2 (0.09 m^2) Surber base will be scrubbed with a nylon brush to remove invertebrates and organic matter. Organic matter retained by the net will be drained onto a 600 µm sieve, placed in plastic bags, and preserved in 70 percent isopropyl alcohol. In the laboratory, samples will be lightly rinsed with water in a 600 µm (standard #30) sieve. Macroinvertebrates will be removed by hand under magnification, identified to the lowest possible taxonomic level (typically genus), and counted. Large samples (>300 individuals) will be sub-sampled using a white tray subdivided into four quadrants. Samples will be evenly distributed across the tray, and each quarter picked until a minimum of 300 individuals is reached (typically ¼ or ½ of the original sample). Large samples will also be viewed in their entirety before sub-sampling; large and/or rare taxa found in this search will be removed and added to the sample total.

The analysis will include identifying taxa present; estimating aquatic invertebrate density and taxa richness; and calculating ratios of mayflies, stoneflies, and caddis flies versus all other aquatic invertebrate taxa. Multiple sampling sites will be established in the restored drainages and ponds (excluding the Wash Plant Area).

Lower trophic level sampling for periphyton standing crop would be conducted in concert with aquatic invertebrate sampling. Periphyton sampling sites will be established within newly created stream reaches, 10 rocks per site will be sampled. Samples will be processed to measure chlorophyll a, b, and c concentrations to produce an estimate of periphyton standing crop and basic community structure determination. Chlorophyll analysis will show overall productivity of the community as well as potential shifts in community structure over time by examining the relative ratios of chlorophyll a, b, and c.

Fish monitoring will be conducted annually for at least five years after construction or longer if performance standards are not met. Monitoring will occur in both pond and stream habitats within the PRM areas (excluding the Wash Plant Area) beginning in the first open water season after construction. A combination of fyke nets in pond habitats and minnow traps in stream habitats will be employed to provide documentation of fish using the mitigation habitats. Sampling will be timed to document various important life history phases for fish anticipated to use the habitats. For example, some sampling will occur each spring to detect spawning grayling, and some sampling will occur each fall to document spawning coho salmon. Generally, most fish sampling efforts will be during mid-summer to identify peak uses by all species. Monitoring timing will be consistent from year to year for comparability of results.

Wetland Monitoring

Monitoring of wetland hydrology and wetland revegetation will be conducted annually for at least 5 years after construction. The wetland monitoring will occur during the same period each year before July 1. Monitoring timing may be adjusted for yearly variations in the onset of the growing season. One monitoring point will be sited for every 5 acres that are revegetated to adequately monitor trends in establishing plant communities. Point locations will be monumented with a Global Positioning System (GPS) device as well as physically, using rebar stakes and flagging to facilitate revisit. At these locations, a pit will be dug (unless surface water is present) to observe hydrology, and the percent coverage of individual plant species (native and non-native), bare ground, and surface water will be recorded. Vegetation data will be compiled within a 10-square-meter (m^2) plot for shrub communities and a 1-m^2 plot for herbaceous communities. Wetland monitoring data will be compared to the performance standards to determine if additional management actions are necessary. Non-native plant recruitment data may specifically lead to active measures to remove non-native plants from restoration areas.

Terrestrial Habitat (Revegetation) Monitoring

Monitoring of terrestrial revegetation will be conducted on the same schedule as the monitoring of wetlands. The inspections will occur during the growing season. One monitoring point will be sited for every 5 acres that are revegetated to adequately monitor trends in establishing plant communities. Point locations will be monumented with a GPS device as well as physically, using rebar stakes and flagging to facilitate revisit. At these locations, the percent coverage of individual plant species (native and non-native) and bare ground will be recorded. Vegetation data will be compiled within a 10- m^2 plot for shrub communities and a 1-m^2 plot for herbaceous communities. Monitoring data will be compared to performance standards to determine if additional management actions are necessary. Non-native plant recruitment data may specially lead to active measures to remove non-native plants from restoration areas.

Additional Monitoring

In addition to the monitoring necessary to verify compliance with the performance standards, Donlin Gold will also monitor stream flows. A stream flow gage with a documented stage-flow relationship will be established on one or more of the streams as a surrogate for stream flows in all restored streams. These gauges will be established upstream of the restoration work on the restored tributaries and will serve as a baseline for assessing the performance of the restoration channels across different flow regimes. The gauges will be established within the stable cross-sections of natural channels. They will be monitored via recording water level sensors (i.e. pressure transducers) during the open water season beginning in the first season after construction and continuing for the duration of the stream channel monitoring program.

Monitoring Reports

Monitoring reports will be produced for each year of post-construction monitoring and submitted to USACE by the end of January of the following year. The results of all stream channel, wetland, terrestrial habitat, stream flow, and fish monitoring will be summarized. Each monitoring report will specifically include a description of each performance standard and identify if the standard has been achieved. If performance standards are not progressing as anticipated, adaptive management actions will be provided to USACE for approval as necessary.

At the end of all monitoring activities, a monitoring closeout report will be completed for the entire PRM area for review and acceptance by USACE. The monitoring closeout report will briefly summarize the findings of the monitoring activities and describe how the PRM has met the performance standards. In addition, the monitoring closeout report will formally request closure of the post-construction monitoring period.

Performance Standards

The following is a discussion of the performance standards that will be used to judge the functional performance of the Upper Crooked Creek PRM. These standards are broken out into three categories targeting restored stream channels, restored wetlands, and restored terrestrial habitats. In specifically using reference reaches, Donlin Gold will compare the PRM to other streams, whereby "success" will be measured as the new stream reaches fall within the targeted design parameters, considering the natural variability of other sample sites in the monitoring program.

Stream Channel Performance Standards

The primary basis of these performance standards is the United States Environmental Protection Agency (EPA) framework for stream function assessment (Harman et al. 2012) Appendix A-d Performance Standards Table. This table lists specific performance standards that can be used to assess stream restoration projects. Each parameter is measured and assigned a score of Functioning, Functioning-At-Risk, or Not Functioning. Functioning-At-Risk can be further classified as degrading toward Not Functioning or improving toward Functioning. Not all parameters in Harman et al. 2012 are appropriate for any specific reconstruction project, and a number are duplicative. Table 17 identifies the parameters and initial proposed performance standards for the Upper Crooked Creek PRM. The final performance standard parameters and values will be approved by USACE along with the final restoration design prior to construction. The EPA standards for stream function contain some parameters for riparian area revegetation that overlap with the wetland and terrestrial revegetation performance standards listed in other criteria.

For compliance, the monitoring of these parameters must show that the stream and floodplain values fall within the categories of Functioning or Functioning-At-Risk (improving) as specified by the EPA criteria. These values must be attained for 3 consecutive years. Additionally, a Functioning score must be achieved in the last of the 3 years for compliance to be attained.

Table 17 Upper Crooked Creek PRM Plan Stream Performance Standards

Parameter	Measurement Method	Performance Standard: Functioning	Performance Standard: Functioning-At-Risk	Performance Standard: Not Functioning
Hydraulic				
Flood Plain Connectivity	Bank Height Ratio (BHR)	1.0 to 1.2	1.3 to 1.5	>1.5
	Entrenchment Ratio	>2.2	2.0 to 2.2	<2.0
Geomorphic				
Large Woody Debris	Large Woody Debris Index (LWDI)	LWDI of project reach equals LWDI of reference reach	LWDI of project reach does not equal LWDI of reference reach, but is trending in that direction	LWDI of project reach does not equal LWDI of reference reach and is not trending in that direction
Channel Evolution	Simon Channel Evolution Model Stages	Sinuous, pre-modified, quasi-equilibrium	Aggrading	Degrading, channelization, widening
Lateral Stability	Meander Width Ratio	>3.5 based on reference reach survey	3.0 to 3.5 as long as sinuosity is >1.2	<3.0
Riparian Vegetation	Buffer Density (stems/acre) Buffer Age, Composition, Growth Canopy Density	Parameter is similar to reference reach condition, with no additional maintenance required	Parameter deviates from reference reach condition, but the potential exists for full functionality over time or with moderate additional maintenance	Significantly less functional than reference reach condition; little or no potential to improve without significant restoration effort
	NRCS Rapid Visual Assessment Protocol	Natural vegetation extends at least one to two active channel widths on each side, or if less than one width, covers entire floodplain	Natural vegetation extends at least one-half to one-third active channel width on each side, or filtering function moderately compromised	Natural vegetation less than one-third active channel width on each side, or lack of revegetation, or filter function severely compromised
Bed Material Characterization	Bed Material Composition	Project reach is not statistically different than reference reach	Not applicable	Project Reach is statistically different (finer) than reference reach

Bed Form Diversity	Percent Riffle	60-70	70-80 40-60	>80 <40
	Pool-to-Pool Spacing Ratio (Slope between 3-5%)	2-4	4 to 6	>6
	Depth Variability (gravel bed streams)	>1.5	1.2 to 1.5	<1.2

Biologic*

Parameter	Measurement Method	Performance Standard		
		Functioning	**Functioning-At-Risk**	**Not Functioning**
Fisheries	As listed in the paragraph above	Fish presence		Fish not present
Macroinvertebrate and Periphyton Communities	As listed in the paragraph above	Exceptional to or similar to reference reach	Impaired showing improvement	Impaired no improvement

*Not based on Harman et al.

Wetland Performance Standards

All floodplain habitat areas addressed by this Plan are expected to become wetlands and meet wetland vegetation and hydrology performance standards.

Wetland Vegetation Performance Standards

Vegetation performance standards have been developed to ensure that revegetated areas are on a trajectory to achieve stability and ecological functionality. Vegetation performance standards will be met at each restoration area. A restoration area will be considered to have achieved the vegetation performance standards when at least 85 percent of monitoring locations satisfy the standards.

The vegetation performance standards are outlined in Table 18. These vegetation performance standards are based on the Draft Oregon Department of State Lands Routine Monitoring Guidance for Vegetation (ODSL 2009). It may be necessary to modify the performance standards for vegetation response to match similarities with reference vegetation communities near the Project. Any proposed modifications will be detailed in the annual monitoring report and submitted to USACE for approval.

Table 18 Wetland Vegetation Performance Standards

Cover of native and/or revegetation hydrophytic* plant species is at least 60 percent.
Cover of invasive species is no more than 10 percent.
Cover of bare substrate is no more than 20 percent.

*Plant species with and indicator status of FAC, FACW, or OBL

Wetland Hydrology Performance Standards

Wetland floodplain habitat will additionally be required to meet wetland hydrology performance standards. The performance standard for hydrology is that the area must meet the wetland hydrology indicators as outlined in the 2008 Alaska Regional Supplement. Wetland hydrology indicators as described in the Alaska Regional Supplement (USACE 2007) will be used as evidence of sufficient hydrology to support wetland habitat formation and function. However, only a subset of the available indicators as described in the Regional Supplement will be used to gauge performance. This subset includes three of the four groups of indicators presented in the supplement (see Table 19). The fourth group, Group D – Evidence from Other Site Conditions or Data, will not be used to gauge hydrologic conditions within the PRM area because landscape variables for the group were derived for natural settings and are not applicable for use in recently constructed wetlands.

One primary indicator from any group is sufficient to conclude that wetland hydrology is present. In the absence of a primary indicator, two or more secondary indicators from any group are required to conclude that wetland hydrology is present. Monitoring for hydrologic indicators will occur within 10-m^2 plots coinciding with the vegetation monitoring. Table 19 lists wetland hydrology indicators to be used for the Upper Crooked Creek PRM.

*Table 19 List of Wetland Hydrology Indicators for Alaska**

Indicator	Category
Group A – Observation of Surface Water or Saturated Soils	
A1 – Surface water	Primary
A2 – High water table	Primary
A3 – Saturation	Primary
Group B – Evidence of Recent Inundation	
B1 – Water marks	Primary
B2 – Sediment deposits	Primary
B3 – Drift deposits	Primary
B4 – Algal mat or crust	Primary
B5 – Iron deposits	Primary
B6 – Surface soil cracks	Primary
B7 – Inundation visible on aerial imagery	Primary
B8 – Sparsely vegetated concave surface	Primary
B9 – Water-stained leaves	Secondary
B10 – Drainage patterns	Secondary
B15 – Marl deposits	Primary
Group C – Evidence of Current or Recent Soil Saturation	
C1 – Hydrogen sulfide odor	Primary
C2 – Dry-season water table	Primary
C3 – Oxidized rhizospheres along living roots	Secondary
C4 – Presence of reduced iron	Secondary
C5 – Salt deposits	Secondary

* Source: USACE 2007.

Terrestrial Habitat Performance Standards

Revegetated and regraded terrestrial habitat areas are expected to meet only terrestrial revegetation performance standards for compliance.

Terrestrial Revegetation

Vegetation performance standards have been developed to ensure that revegetated areas are on a trajectory to achieve stability and ecological functionality. Vegetation performance standards will be met at each restoration area. Achievement of vegetation performance standards will be assessed at locations established after the first full growing season (year 1). An entire restoration area will be considered to have achieved the performance standards when at least 85 percent of monitoring locations satisfy the standards.

The vegetation performance standards are outlined in Table 20. These vegetation performance standards are based on the draft Oregon Department of State Lands Routine Monitoring Guidance for Vegetation (ODSL 2009). It may be necessary to modify the performance standards for vegetation response to match similarities with reference vegetation communities near the Project. Any proposed modifications will be detailed in the annual monitoring report and submitted to USACE for approval.

Table 20 Terrestrial Habitat Vegetation Performance Standards

Cover of native and/or revegetation plant species is at least 60 percent.
Cover of invasive species is no more than 10 percent.
Cover of bare substrate is no more than 20 percent.

Maintenance Plan

The mitigation restoration work plans are designed to eliminate the need for regular maintenance. No artificial structures will be used to regulate hydrology so change should follow the natural evolution and geomorphic process of the watershed. Any failures or deficiencies noted during the monitoring period or the review period associated with the long-term management plan (LMP) will be reported and addressed as part of the Adaptive Management Plan.

Long-term Management Plan (LMP)

As part of finalizing the site protection instrument (deed restriction) for this Plan, Donlin Gold will prepare a LMP for the upper Crooked Creek PRM site. The LMP will be implemented as soon as USACE concurs that performance standards have been achieved in each restoration area. The LMP will be applied by a third party to conduct inspections and provide reports to demonstrate long-term compliance with the deed restriction. Selection of the third party will be subject to USACE review and approval based on their qualifications to serve in this role.

Donlin Gold will submit the LMP to USACE at least 6 months prior to the start of Project construction. Project construction will not be initiated until the deed restriction is in place and the LMP is approved by USACE.

Specifically, the LMP will be designed to ensure that the upper Crooked Creek PRM site is monitored, managed, and maintained for the long-term sustainability and preservation of its restored conditions. The LMP will be intended to extend for the duration of the deed restriction. The LMP will also specifically describe the mechanism by which the proposed third party's inspections and reporting will be funded over the term of the restriction.

To support preparation of the LMP (and finalize the deed restriction), Donlin Gold will complete a metes and bounds survey of the upper Crooked Creek restoration site according to methods acceptable to the USACE. The survey is expected to closely resemble the boundaries represented within this Plan and will be used to establish the exact property boundaries for the deed restriction and LMP. Under the provisions of the LMP, the third party and the landowners will implement methods to limit access to, and restrict activities in, the upper Crooked Creek restoration site where appropriate.

Donlin Gold shall implement the approved LMP for the purposes stated above. The LMP will require annual monitoring site visits by the third party to qualitatively monitor the general conditions of the upper Crooked Creek restoration site and compliance with the terms of the deed restriction. The conditions of the upper Crooked Creek restoration site will be evaluated, documented, and mapped during the site visits. The third party will be responsible for preparing annual monitoring reports detailing the conditions of the upper Crooked Creek PRM site, and any recommended management actions. In the annual reports, the third party will specifically describe if there have been any anthropogenic changes to the status of the upper Crooked Creek PRM site functional values including: waters of the United States (wetlands and streams). The annual monitoring reports will be available to USACE upon request.

As described in the LMP, the landowners will not be responsible for changes to the site conditions attributable to natural catastrophes such as flood, fire, drought, disease, regional pest infestation, and others that are beyond their reasonable control. Active management will not be required for ecological changes that come about because of processes such as climate change, fluctuating river levels, and sedimentation due to overbank flood deposits that may affect the upper Crooked Creek PRM site's streams and wetlands. Over time, natural successional and geomorphic processes could occur that may affect wetland and stream functions or total wetland acreages or linear feet of stream.

Finally, the LMP will describe how Donlin Gold and the third party will work with the landowners to ensure that any activities proposed to occur in the upper Crooked Creek PRM site comply with the requirements of the deed restriction. This will include preventing any activities that are specifically prohibited by the deed restriction, see the Site Protection Instrument Section.

In summary, Donlin Gold proposes that the LMP include the following specific sections:

1. Introduction and Purpose
2. Third party and Responsibilities
3. PRM Area Description
    a. Location and boundaries
    b. Ownership
    c. Land (to be updated after restoration completion)
    d. Baseline conservation values, including wetlands, streams, and WOUS (to be updated after restoration completion)
4. Management and Monitoring

a. Annual Site visits, including Scope, Documentation, and Action Items
    b. Security, safety, and public access
    c. Limits of responsibility, including exclusions for natural events
5. Allowable Improvements and Activities
    a. Permitted and prohibited actions

b. Third party and landowner coordination

6. Adaptive Management
7. Reporting and Administration
8. Amendments, Transfer, Replacement/Termination, and Notice Provisions
9. Funding
10. USACE Rights, Responsibilities, and Authorities
11. Signatures

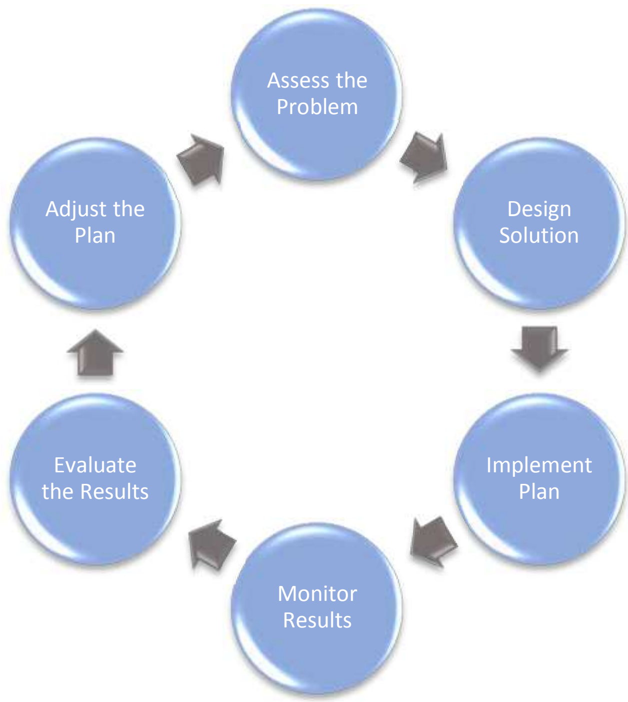
Adaptive Management Plan

There are two stages of adaptive management: (1) adaptive management of the restoration sites to meet performance standards and (2) adaptive management under the LMP to enforce the site protection instrument conditions.

During restoration activities, the adaptive management plan will work toward successful restoration by adjusting and adapting to issues with implementation and onsite conditions. The adaptive management process is designed to deal with the uncertainty of the PRM field program and allow for problem solving and adjustments during design, implementation, and long-term PRM management. To have a successful PRM Plan, Donlin Gold understands it will be necessary to follow six steps in an adaptive management process (Figure 4). Within each step, several essential elements will be completed. Adaptive management is a process of connecting and linking the information from the PRM design, implementation, construction, monitoring, and evaluation phases to ensure that the initial design functions and meets the intended standards and objectives. If monitoring demonstrates that a corrective action is needed, Donlin Gold will adjust the work plan to meet the performance standards of the Plan. Adaptive management continually evaluates the results and adjusts work elements to meet the overall objective (Ministries of Forests and Range 2008). Donlin Gold is fully committed to this framework for a successful PRM Plan.

After restoration is completed and the performance standards are met, adaptive management will be conducted as described in the LMP. As discussed above, annual monitoring reports will be completed documenting updated site conditions. The annual reports will identify any areas of concern (i.e., occurrence of prohibited activities) along with any necessary corrective or remedial actions.

Figure 4 Adaptive Management Cycle



Source: Ministries of Forests and Range 2008

Financial Assurances

Donlin Gold is committed to providing a full financial assurance estimate for the restoration work when the final design is submitted for USACE approval[1]. Once a value is agreed upon, Donlin Gold will cover that amount with a bond instrument acceptable to USACE prior to commencing work authorized by the Department of Army Permit. Further details of the financial assurance estimate and instrument for the Upper Crooked Creek PRM are described below.

Donlin Gold is fully responsible for providing financial assurance for activities related to the restoration, construction, and monitoring work. The mitigation rule states that "*In determining the assurance amount, the district engineer shall consider the cost of providing replacement mitigation, including costs for land acquisition, planning and engineering, legal fees, mobilization, construction and monitoring*" [33 CFR 332.3(n)(2). However, the guidance provided to the district engineer explains that "Not all component costs listed above might be applicable in every case. Land cost, which is often the single largest project cost component in many areas of the country, may or may not be relevant for determining assurance amounts…..If it is believed that the mitigation project remediation would be desirable and likely to be successful (e.g., the mitigation site is an excellent candidate for a successful restoration project), then there would be no need to include component costs for land purchase when

[1] Donlin Gold requests that this be included as a special condition to the permit and that a final assurance amount along with an accepted financial instrument will be approved and in place prior to construction

setting assurance amounts." With this background, Donlin Gold provides the following information as the basis for the financial assurance estimate.

Donlin Gold does not propose that land costs be included in the financial assurance for the following reasons:

1. The project sites have all of the elements required to provide an excellent candidate for a successful restoration project;
2. Donlin Gold being a mining company, located adjacent to the proposed restoration site, will have the equipment, resources and expertise to not only maintain the sites during the monitoring period, but will have the capacity to revise designs and reconstruct should the need arise;
3. The land owners have concurred with preserving the areas being considered for wetlands and stream restoration and preservation, and have extensive additional land holdings in the HUC-10 if the need arises to relocate the project sites as contemplated by the Rule.

Based on the above reasons, Donlin Gold does not propose any amount for land acquisition in the financial assurance estimate. Donlin Gold has included engineering redesign fees as one of the indirect cost components to allow for re-engineering the sites, if the need arises, prior to meeting performance standards (discussed in further detail below).

For the construction costs of building the restoration sites, Donlin Gold will follow standard cost estimation procedures for reclamation-type activities. BLM has a publically available spreadsheet program[2] that Donlin Gold used to provide the financial assurance estimate to the State of Alaska for the full mine site reclamation and closure activities; the spreadsheet program is known as SRCE (Standardized Reclamation Cost Estimator). This program has been widely used by industry and accepted by regulatory agencies for generating small and large reclamation project cost estimates. The approach used, in compliance with the requirements of the Rule, is to ensure that USACE, through a third party, has access to the funds to hire a contractor to complete the proposed restoration work, if necessary.

The construction component of the estimate will contain the elements described below. Donlin Gold proposes to apply the same inputs used for the existing reclamation cost estimate for the mine site that have been reviewed and approved by the Alaska Department of Natural Resources – Division of Mining, Land and Water's Mining Section and the Alaska Department of Environmental Conservation – Division of Environmental Health's Solid Waste Program. These agencies review and implement reclamation project cost estimates in all regions of the state for large and small mine projects and have extensive experience in this subject. Their preference for estimating project costs is to use SRCE.

[2] Available for download at https://nvbond.org/srce_downloads/

Table of Inputs

- Labor rates – Alaska Davis Bacon wages (Pamphlet 600) latest update
- Equipment hourly rates – based on quotes and cost sheets from equipment suppliers in the region
- Fuel and material costs – based on local quotes delivered to site

Earthworks and Direct Costs

Material excavation: The current estimate of excavation requirements for the combined restoration sites is 430,000 cubic yards (CY). The majority of this work will be done via a track mounted excavator. Some excavation may be conducted by wheel loader. For the final cost estimate, each site will be examined to determine a more refined excavation rate (CY per hour) for that specific portion of the project. The final cost estimate then becomes a calculation of the volume of material divided by the excavation rate to determine the number of equipment hours needed. The hours will be multiplied by the hourly cost (equipment plus labor plus fuel) to determine the estimated excavation cost. The site details to generate final volumes and productivity rates are not currently available at this level of design. However, a preliminary estimate has been made by multiplying the volume times the typical bid tab[3] rate for that activity managed by the State of Alaska's Department of Transportation and Public Facilities (ADOTPF). Excavation rates are roughly $0.50 per CY, making the engineering estimate for this component $215,000.

Loading and hauling costs (for excess material): The current designs indicate that there will be 258,000 CY of excess material that will need to be loaded and hauled offsite for storage. There is ample capacity in the overburden stockpiles identified in the mine permit's footprint for this material. Cost estimating for this component follows similar reasoning to the excavation calculation, but adds the costs of trucks and bull dozers. A detailed estimate requires an analysis of the haul route and distance to determine how many trucks will be required for a given production rate. A fully loaded cost for the fleet is multiplied by the number of fleet hours estimated to arrive at an overall cost for loading and hauling of excess material. For the preliminary engineering estimate, Donlin Gold applied a unit rate of $3.00 per CY to the 258,000 CY of excess material to calculate a cost of $774,000 for this cost component.

Processing and importing of select sized material (if needed): Construction of the stream channels will likely require the import and placement of appropriately sized gravel material for construction of the pool-riffle-run sequences. The amount of this material has not been defined at this level of design but would be included in the final designs to be provided to USACE for approval. The remnants from the past placer mining activity provide an ample source supply for gravel. This component would include screening of the material located near the site to generate the correct volume and size requirements of material for placement into the stream channel beds. No preliminary estimate of this amount is

[3] A bid tab is short for bid tabulation; this is a historic tracker spreadsheet ADOT manages that shows the bid cost by contractors for different projects throughout the state, broken down by bid component. These bid tab costs are often used to generate an engineering estimate for projects before they go out for bid

available at this time. An estimate for 8,982 feet of channel, 1 foot thick and 6 feet wide would require roughly 2,000 CY of sized stream bed material.

Stream construction activities (placement of bank protection): The construction of the stream sections will entail special consideration to the stream banks. This may include temporary waddles with willow plantings, embedding woody debris roots into the stream bank, or sections with boulders or rip rap armoring. The details for this level of cost estimating are not available at this time but will be included in the final cost estimate. For the preliminary engineering estimate, Donlin Gold assumed $60 per lineal foot of stream multiplied by 8,982 feet of stream channel to calculate a component cost of $224,550.

Other project elements (e.g., culverts): The only other project elements (structure) identified at this time are two culvert crossings for the access road between the mine area and the restoration areas. A full fish passage culvert design will be provided for the final design approval and included in the final cost estimate. For the preliminary engineering estimate, Donlin Gold has assumed 60 feet of culvert at an installed rate of $100 per lineal foot, or $6,000 for this cost component.

Topsoil placement: Restoration of the area will require importation and placement of topsoil in the reclaimed areas. The current design identifies 59 acres of upland and wetland area that will require soil placement. This number will be refined in the final design as additional details are available. The cost of placement is estimated similar to the loading and hauling component above. The fleet would include a loader at the source, trucks to haul topsoil to placement sites, and a bull dozer to spread the material. Scrapers could be used in lieu of the loader and trucks. Assuming an average of 18 inches of soil placement, this would require 142,780 CY of soil. Applying a unit rate of $2.50 per CY placed, the preliminary estimate for this cost component is $356,950.

Re-vegetation (both seed and seedlings as required): The final step in the construction process is applying seed and transplanting seedlings in the restored areas. This includes the cost of labor, equipment (spreaders, planters) and materials (seed, seedlings). The current Donlin Gold SCRE model estimates this to be $340 per acre for similar sized areas. Based on the 59 acres identified for revegetation needs, the preliminary estimate for this component is $14,750.

Summing the components identified above, the subtotal for the preliminary engineering estimate for direct costs for the restoration area work is $1,596,560.

<u>Indirect Cost Items (generally a percentage of direct costs)</u>

Mobilization/demobilization of equipment and crews to/from site: While equipment will be on site to support mine activities, the cost estimate will assume that a contractor would need to mobilize and demobilize equipment to and from the project site. Current freight rates from Anchorage to the Jungjuk Port site are estimated at $265 per ton. Applying a 10 percent cost to the direct cost (on the high side of a typical range, accounting for the remote location), the preliminary estimate includes $159,656 for mobilization and demobilization. This would provide for 300 tons of equipment to be transported to and from the site. A more detailed breakdown will be provided with the final estimate when a full equipment list is available.

Contingency (typically 4 to 8 percent): The Donlin Gold SRCE model identifies a range of suggested contingency values that are a function of the overall project cost. They recommend 10 percent to be used for small projects (<$500,000) ranging down to 4 percent for large projects (>$50 million). Donlin Gold used the recommended 8 percent for this estimate (<$5,000,000).

Construction management (2 to 4 percent): This covers the cost for the contractor site foreman and other administration staff to support the field efforts. The Donlin Gold SRCE modeling approved by the agencies has a 1.1 percent cost for this component, but it is for a much larger project. Donlin Gold increased this to 5 percent, allowing for $79,828 for site construction management.

Engineering redesign fee (typically 4 to 8 percent, depending on complexity): This cost component allows for engineering support in the event that the restoration project is not performing as planned and adjustments need to be made. Due to the small size of the project and the level of engineering design expected for the final design, Donlin Gold has included a 4 percent engineering contingency, which is $63,862.

Contractor profit (10 percent): This is a typical, standard cost component rate to allow for profit for the contractor. For this project, a $159,656 profit has been included.

Management fee for agency/third party (4 to 6 percent): This is money available to the third party administrator to cover their costs to oversee the contract on behalf of USACE for completing the scope of work. Donlin Gold has included 5 percent of the direct costs, which is $79,828.

Overall, the indirect costs are $670,555, or 42 percent of the direct costs. This is at the high end of what indirect costs typically add to a reclamation cost estimate and should be sufficient for accomplishing the construction phase of the project.

A detailed cost estimate will be provided based on the final design approved by USACE prior to construction. For planning purposes, a preliminary engineering cost estimate prepared using the current volumes from the design contained in this Plan totals $2,267,115, including $1,596,560 in direct costs and $670,555 in indirect costs.

Long-Term Monitoring and Reporting: Donlin Gold will provide a separate estimate for the ongoing maintenance, monitoring, and reporting as prescribed in the LMP. Donlin Gold has not provided a preliminary estimate for these at this time, since the LMP has yet to be prepared and approved.

Form of Financial Assurance: The form of financial assurance will comply with those mechanisms identified in the IWR March 2016 report, “Implementing Financial Assurance for Mitigation Project Success,” Section 2.5, Instruments. The most likely form will be a letter of credit, performance bond, or escrow agreement. Donlin Gold will also establish an agreement with a third party to be approved by USACE that will be the beneficiary of the financial assurance instruments to carry out any construction corrections and to assure the monitoring and reporting are conducted out as required. This can take the form of a trust agreement with the chosen third party. Donlin Gold requests that the details of that be provided for in a special condition of the DA permit to allow time for those details to be worked out prior to construction.

References

Alaska Department of Fish and Game (ADF&G). 2005. Streambank Revegetation and Protection Guide. Revised 2005. Division of Sport Fish.

ADF&G. 2010. Catalog of Waters Important for the Spawning, Rearing, or Migration of Anadromous Fishes. http://www.adfg.alaska.gov/sf/SARR/AWC/

Alaska Department of Natural Resources (ADNR). 1988. Kuskokwim Area Plan for State Lands.

Carlson, M., I. Lapina, M. Shephard, J. Conn, R. Densmore, P. Spencer, J. Heys, J. Riley, and J. Nielsen. 2008. Invasiveness ranking system for non-native plants of Alaska. United States Department of Agriculture Forest Service, R10-TP-143. 218 pp.

Czapla, P.K. and S.J. Wright. 2012. Interior Alaska Re-vegetation and Erosion Control Guide. Alaska Plant Materials Center.

Donlin Gold, LLC (Donlin Gold). 2014. Permittee Responsible Mitigation Plan Upper Crooked Creek Watershed. Prepared by 3 Parameters Plus, Inc. August 28, 2014.

Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, and C. Miller. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Washington D.C. EPA 843-K-12-006.

Michael Baker International. 2016. Preliminary Jurisdictional Determination Donlin Gold Project, Southwest Alaska. Prepared for Donlin Gold, LLC. December.

Ministries of Forests and Range (British Columbia, Canada). 2008. An Introductory Guide to Adaptive Management for Project Leaders and Participants. Retrieved from http://www.for.gov.bc.ca/hfp/amhome/index.htm.

Moody, C. 2015. EIS Team Request for Invasive Species Survey Data Near the Mie Site. January 15, 2015. Project No. 104.1.3.3. Memo from Cheryl Moody, Three Parameters Plus, Inc. to Enric Fernandez, Donlin Gold, LLC. 27 pp. Cited in: U.S. Army Corps of Engineers. 2018. Donlin Gold Project Final Environmental Impact Statement. April 2018.

Nawrocki, T., H. Klein, M. Carlson, L. Flagstad, J. Conn, R. DeVelice, A. Grant, G. Graziano, B. Million, and W. Rapp. 2011. Invasiveness Ranking of 50 Non-Native Plant Species for Alaska. Report prepared for the Alaska Association of Conservation Districts. Alaska Natural Heritage Program, University of Alaska Anchorage, Anchorage, Alaska. 253 pp.

Natural Resource Conservation Service (NRCS). 2008. Soil Survey of Western Interior Rivers Area, Alaska. Publication of the National Cooperative Soil Service. United States Department of Agriculture.

Oregon Department of State Lands L (ODS). 2009. Routine Monitoring Guidance for Vegetation. A Companion Document to the Compensatory Mitigation for Non-Tidal Wetlands and Tidal Waters and Compensatory Non-Wetland Mitigation. OAR 141-085-0680 to 141-085-0765. Interim Review Draft version 1.0. September 23.

OtterTail Environmental Inc. (OtterTail). 2012. 2012 Aquatic Biomonitoring Report: Donlin Gold Project, 2004 through 2012 data compilation. Prepared for Donlin Gold, LLC.

OtterTail. 2014. 2014 Aquatic Biomonitoring Report: Donlin Gold Project, 2004 through 2014 data compilation. Prepared for Donlin Gold, LLC.

Peters, J.A. and D.M. Lodge. 2009. Littoral Zone. University of Notre Dame, Notre Dame, IN. https://www.climate-policy-watcher.org/lake-ecosystems/littoral-zone.html. Accessed 10/24/2017.

Rosgen, D. and H.L Silvey. 2006. Applied River Morphology. Second Edition. Wildland Hydrology. Fort Collins, Colorado.

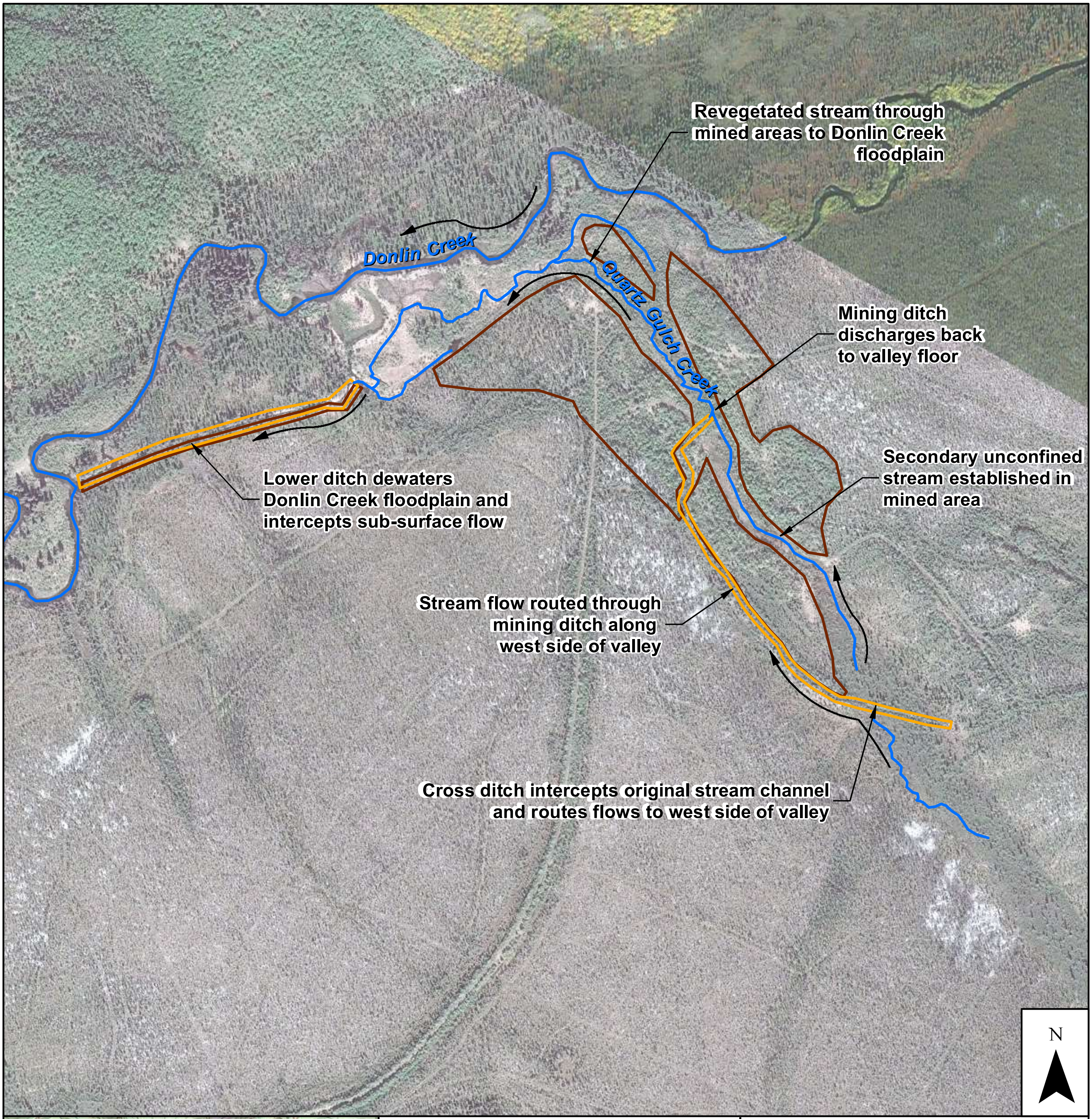
USACE (United States Army Corps of Engineers). 2007. Regional Supplement to the United States Army Corps of Engineers Wetland Delineation Manual: Alaska Region, (Version 2.0), ed. J.S. Wakeley, R.W. Lichvar, and C.V. Noble. ERDC/EL TR-07-24. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

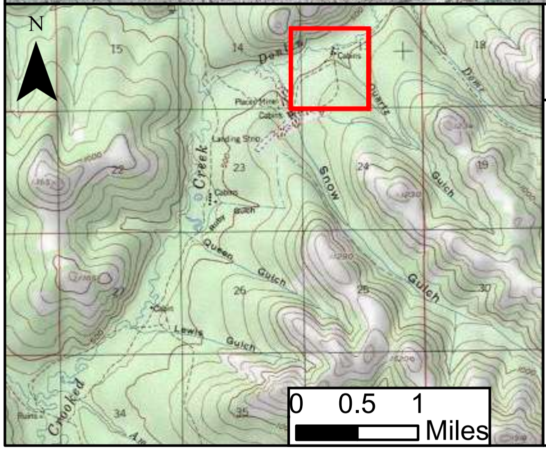
United States Army Corps of Engineers and Environmental Protection Agency (USACE and EPA). 2008. 33 CFR 332; 40 CFR Part 230. Compensatory Mitigation for Losses of Aquatic Resources, Mitigation Rule. April 10, 2008.

United States Geological Survey (USGS). 2017. National Hydrography Geodatabase: The National Map viewer available https://viewer.nationalmap.gov/viewer/nhd.html?p=nhd, accessed 9/8/17.

United States Geological Survey (USGS). N.D. EarthExplorer Historical Imagery. Retrieved from https://earthexplorer.usgs.gov/.

Appendix D-1, Figures 2 – 13





0 400 800
Feet

Existing Site Features

- Ditch
- Overburden
- Existing Streams
- FlowPath

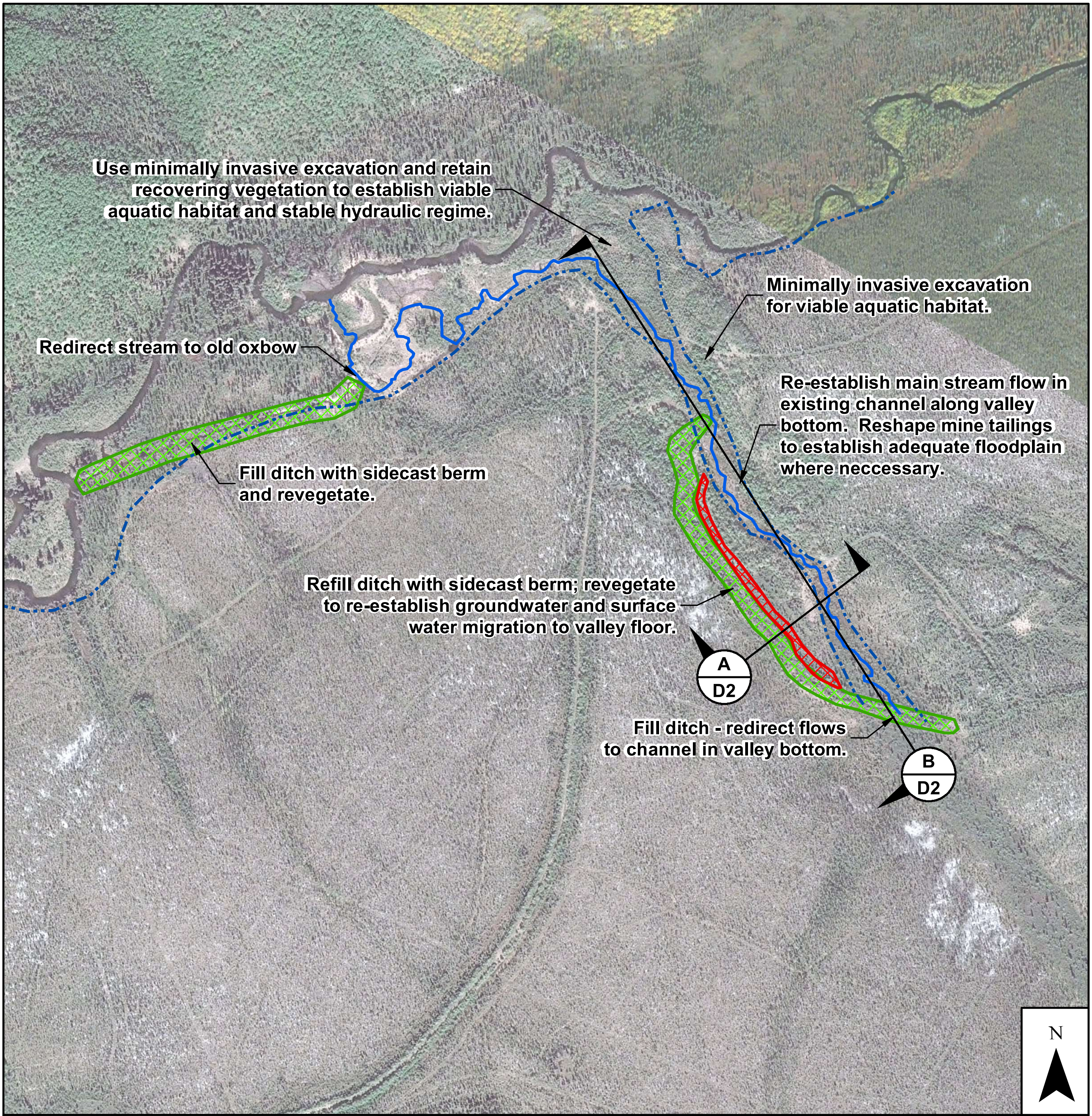
Compensatory Mitigation Plan
Attachment D, Upper Crooked Creek PRM Plan, Appendix D-1

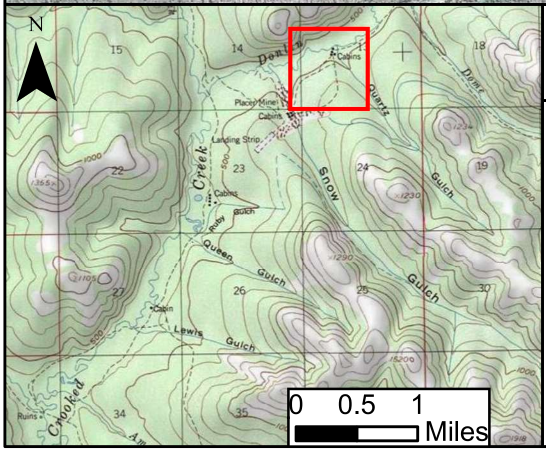
Quartz Baseline Conditions

NAD 1983 UTM Zone 4N;
Imagery 0.5 m resolution, capture date 5/29/2016

DONLIN GOLD

Figure 2





0 400 800
Feet

Grading Plan

- Regrade Cut
- Regrade Fill
- Proposed Floodplain Boundary
- Proposed Stream Thalweg

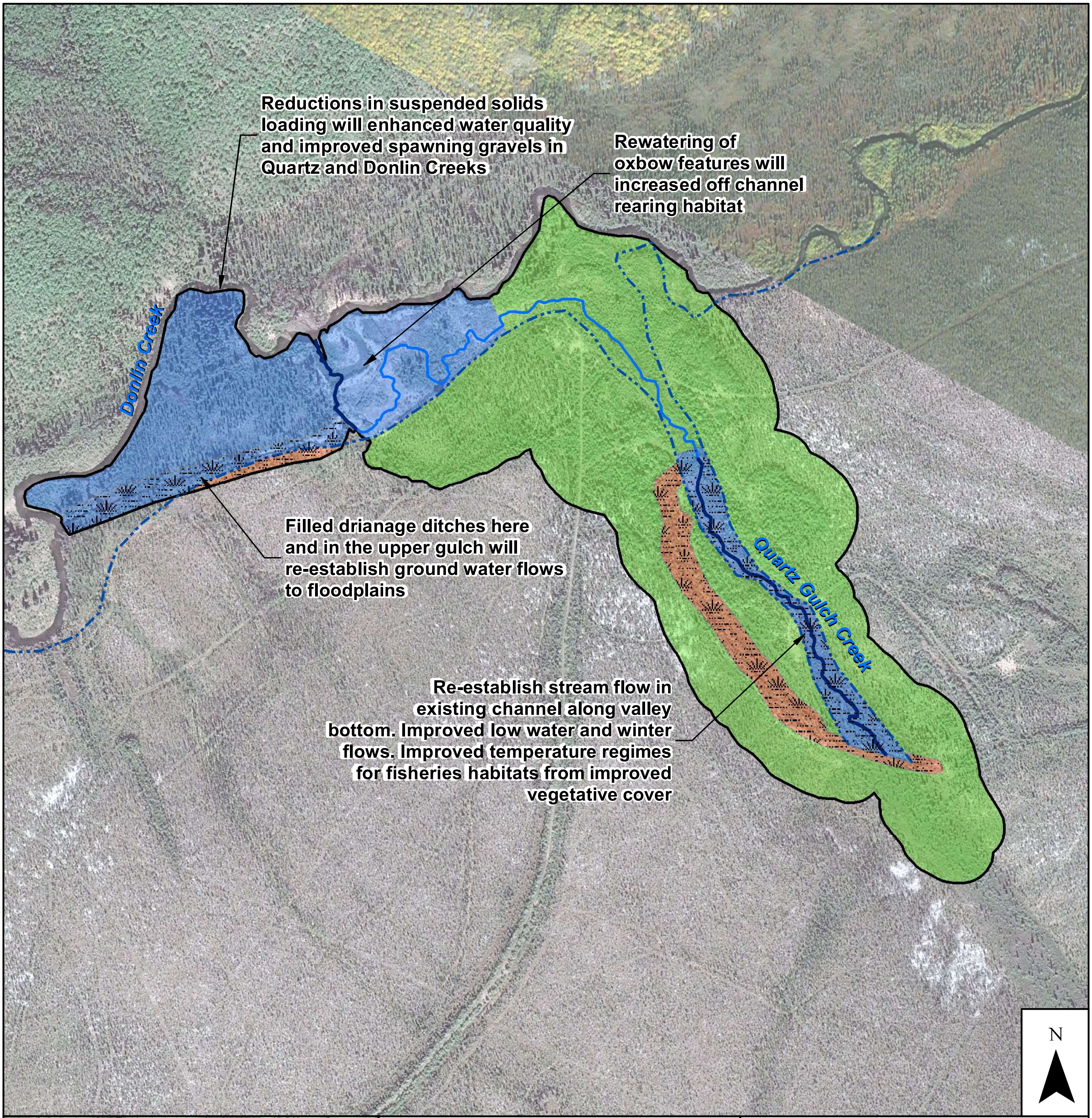
Compensatory Mitigation Plan
Attachment D, Upper Crooked Creek PRM Plan, Appendix D-1

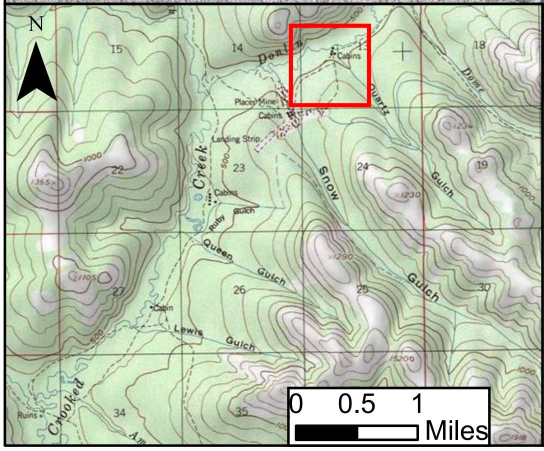
Quartz Construction Plan

NAD 1983 UTM Zone 4N;
Imagery 0.5 m resolution, capture date 5/29/2016

DONLIN GOLD

Figure 3





0 400 800
Feet

Floodplain Boundary
Stream

Restoration Activity

Re-established Stream Channel
Re-established Floodplain
Enhanced Terrestrial Habitat
Protection Buffer
Revegetation Area

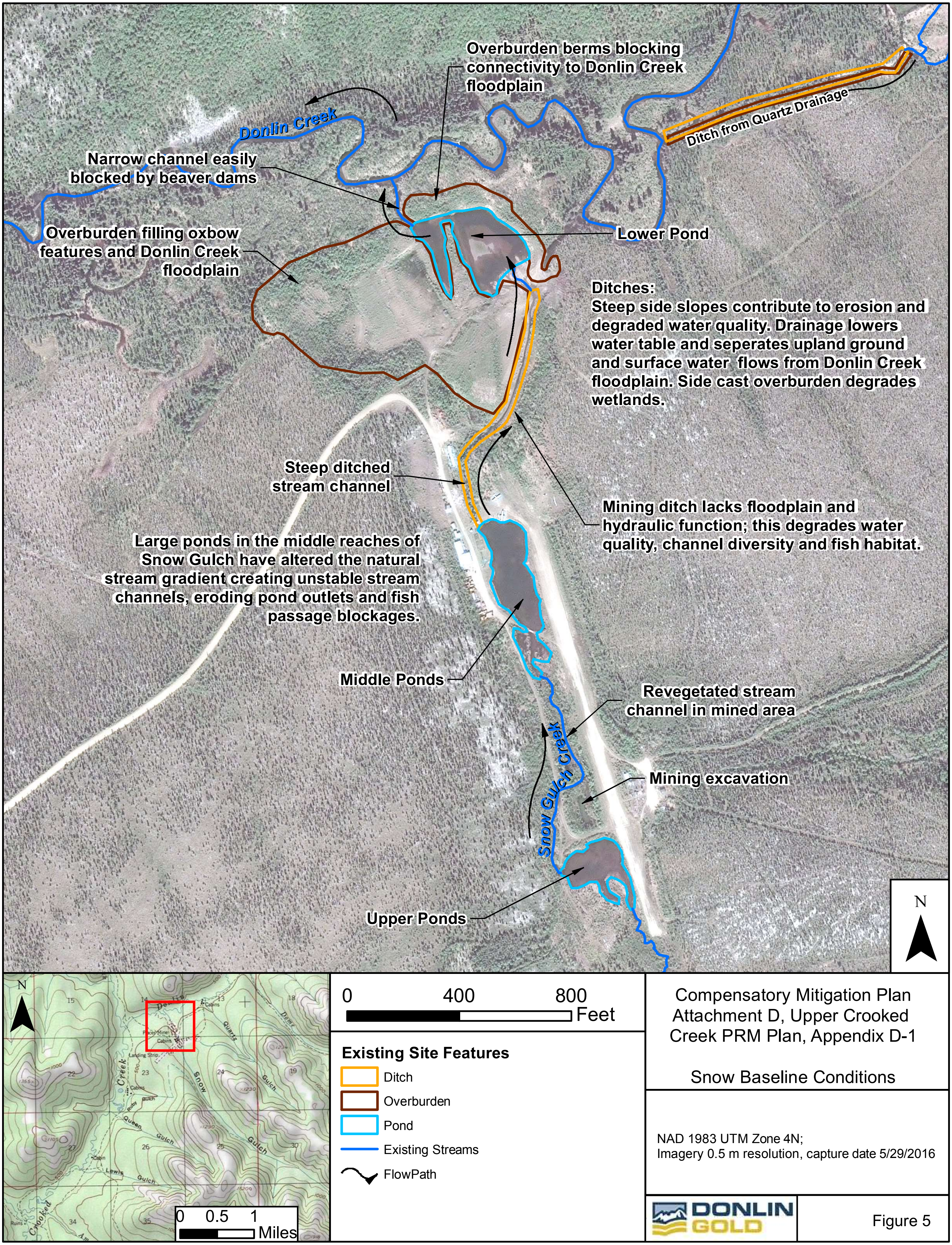
Compensatory Mitigation Plan Attachment D, Upper Crooked Creek PRM Plan, Appendix D-1

Quartz Post-Construction

NAD 1983 UTM Zone 4N;
Imagery 0.5 m resolution, capture date 5/29/2016

DONLIN GOLD

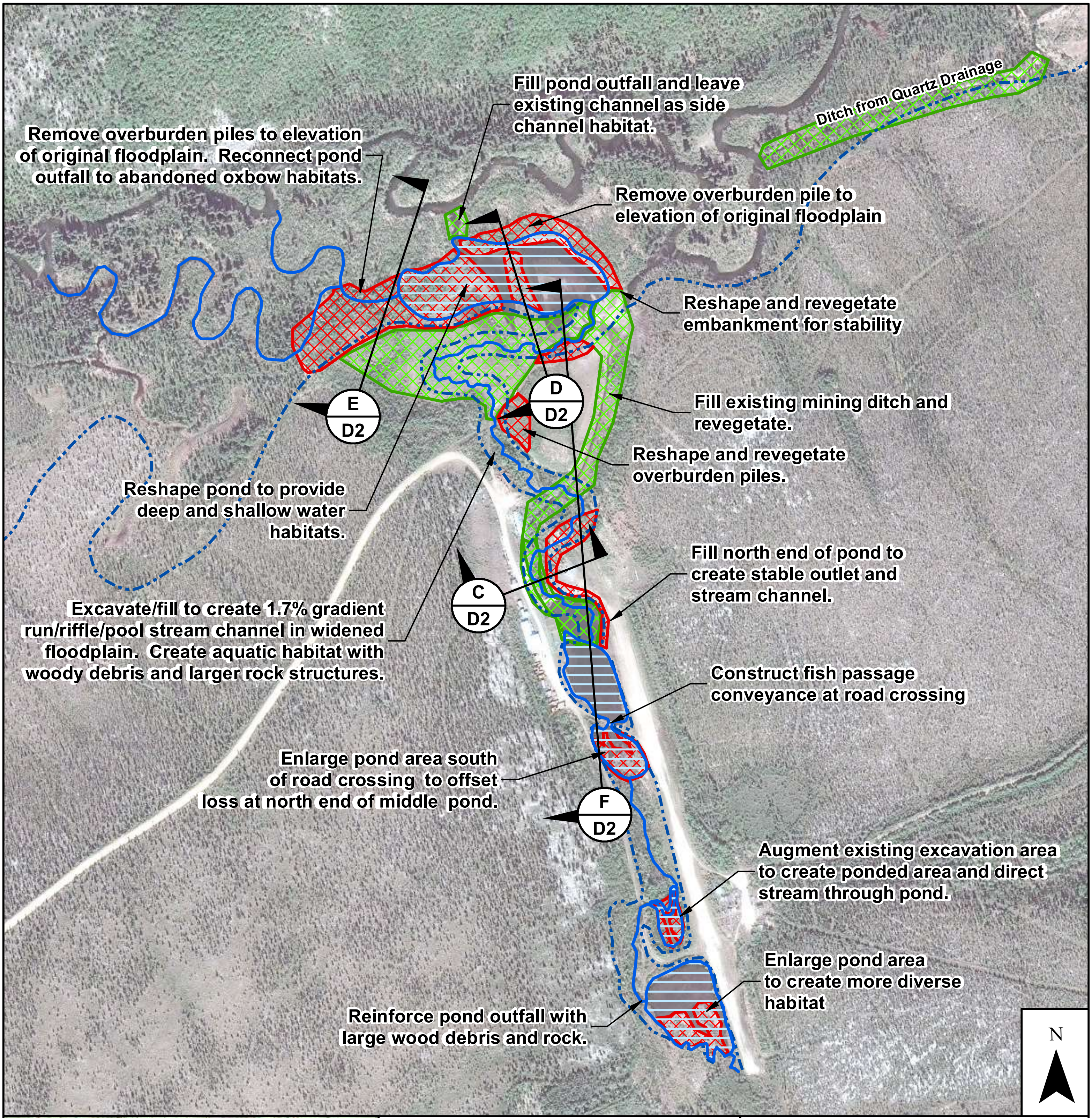
Figure 4

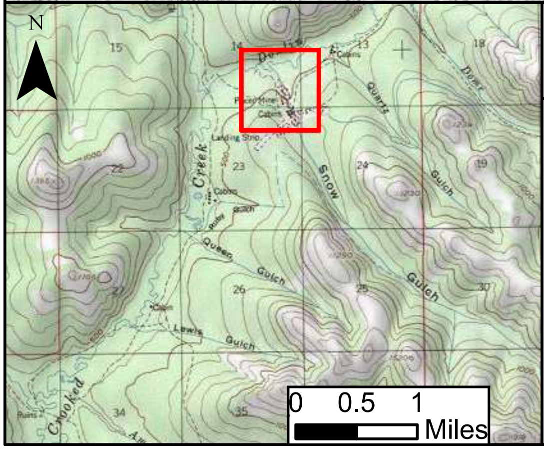


Compensatory Mitigation Plan Attachment D, Upper Crooked Creek PRM Plan, Appendix D-1

Snow Baseline Conditions

Figure 5





0 400 800
Feet

Grading Plan

- Regrade Cut
- Regrade Fill
- Proposed Pond
- Proposed Floodplain Boundary
- Proposed Stream Thalweg

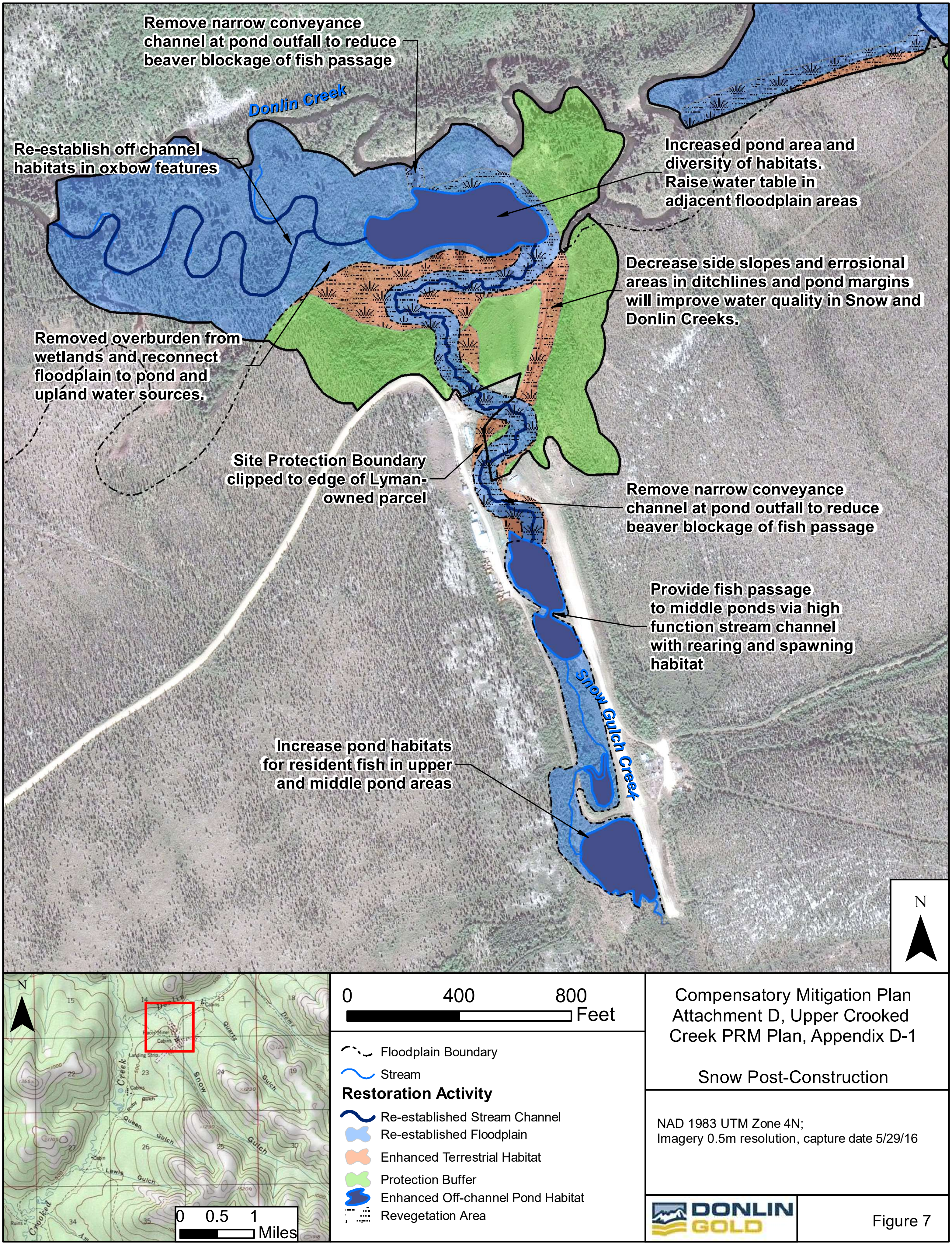
Compensatory Mitigation Plan
Attachment D, Upper Crooked Creek PRM Plan, Appendix D-1

Snow Construction Plan

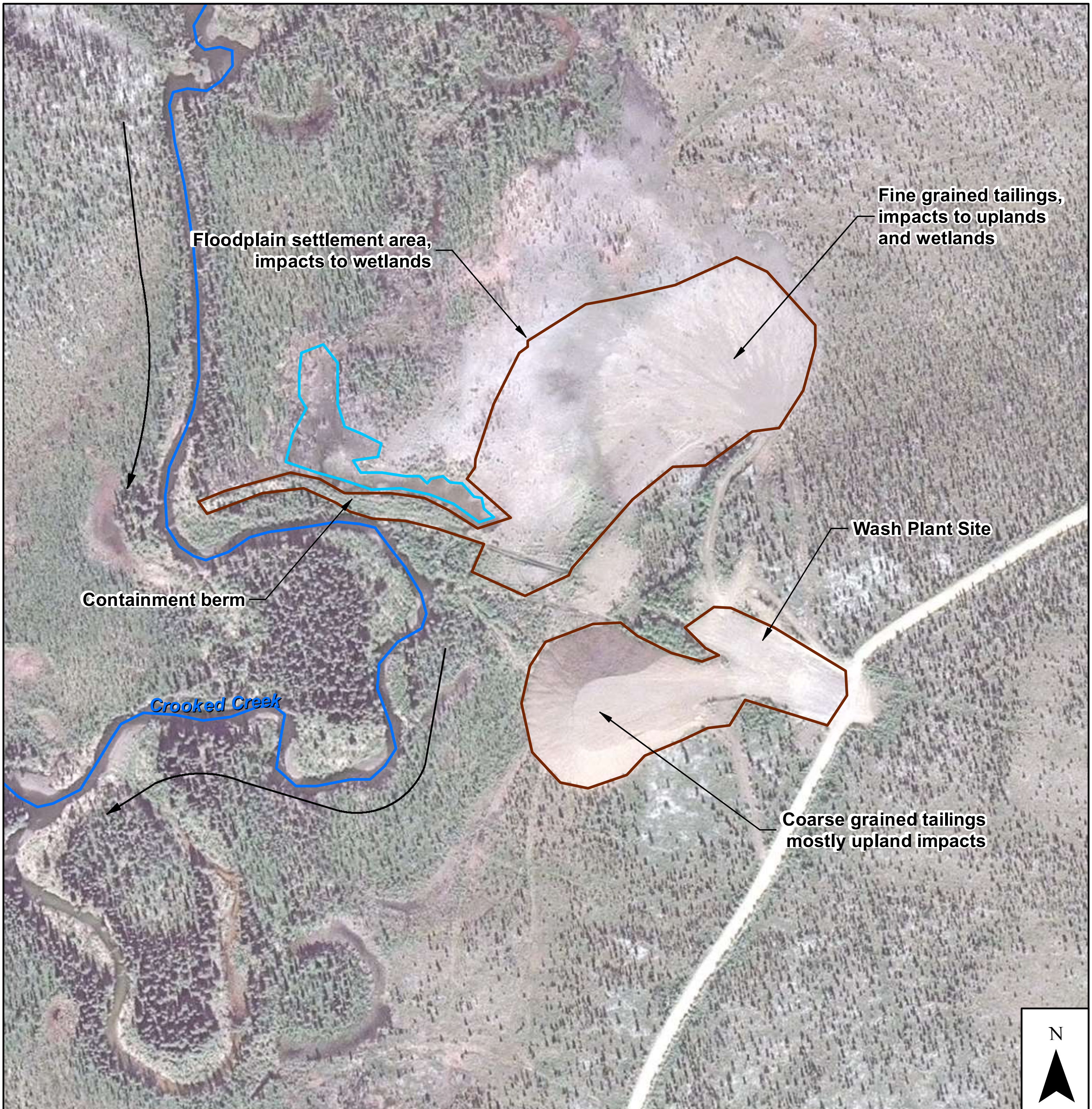
NAD 1983 UTM Zone 4N;
Imagery 0.5 m resolution, capture date 5/29/2016

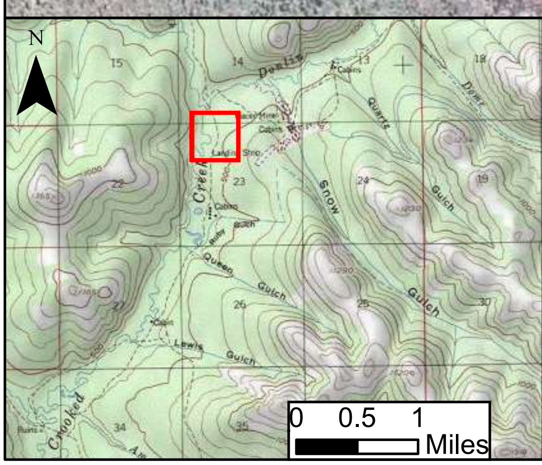
DONLIN GOLD

Figure 6



Remove narrow conveyance channel at pond outfall to reduce beaver blockage of fish passage
Donlin Creek
Re-establish off channel habitats in oxbow features
Increased pond area and diversity of habitats. Raise water table in adjacent floodplain areas
Decrease side slopes and errosional areas in ditchlines and pond margins will improve water quality in Snow and Donlin Creeks.
Removed overburden from wetlands and reconnect floodplain to pond and upland water sources.
Site Protection Boundary clipped to edge of Lyman-owned parcel
Remove narrow conveyance channel at pond outfall to reduce beaver blockage of fish passage
Provide fish passage to middle ponds via high function stream channel with rearing and spawning habitat
Snow Gulch Creek
Increase pond habitats for resident fish in upper and middle pond areas
N
0 400 800
Feet
0 0.5 1
Miles
Floodplain Boundary
Stream
Restoration Activity
Re-established Stream Channel
Re-established Floodplain
Enhanced Terrestrial Habitat
Protection Buffer
Enhanced Off-channel Pond Habitat
Revegetation Area
Compensatory Mitigation Plan Attachment D, Upper Crooked Creek PRM Plan, Appendix D-1
Snow Post-Construction
NAD 1983 UTM Zone 4N;
Imagery 0.5m resolution, capture date 5/29/16
Figure 7





0 237.5 475
Feet

Existing Site Features

- Ditch
- Overburden
- Pond
- Existing Streams
- FlowPath

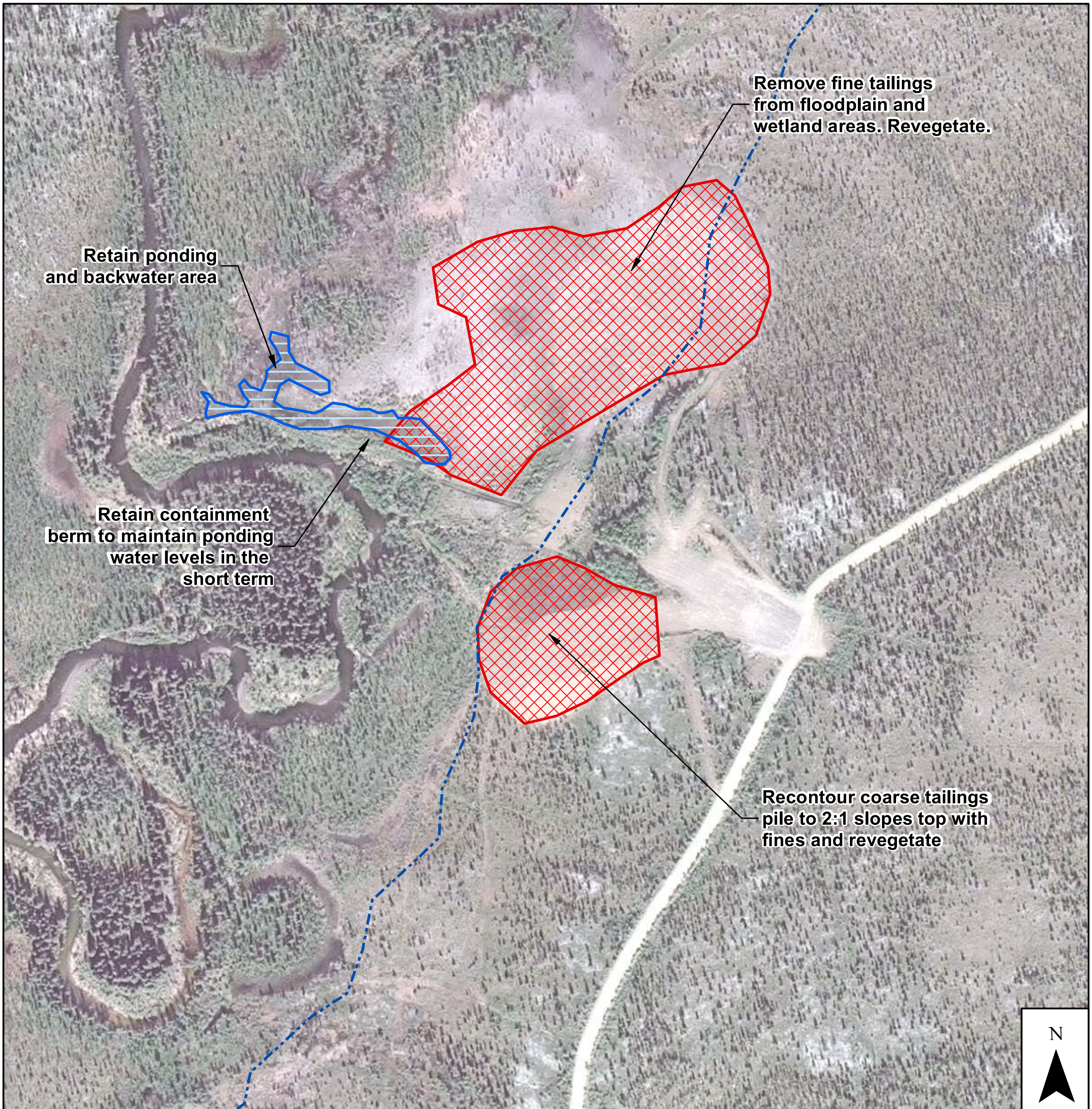
Compensatory Mitigation Plan
Attachment D, Upper Crooked
Creek PRM Plan, Appendix D-1

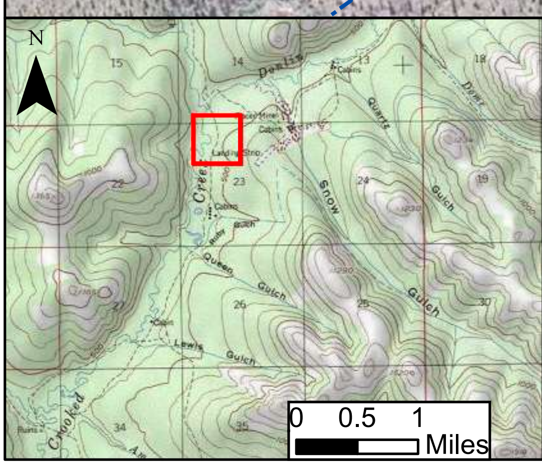
Wash Plant Tailings
Baseline Conditions

NAD 1983 UTM Zone 4N;
Imagery 0.5 m resolution, capture date 5/29/2016

DONLIN GOLD

Figure 8





0 250 500 Feet

Grading Plan

- Regrade Cut
- Proposed Flood Plain Boundary
- Pond

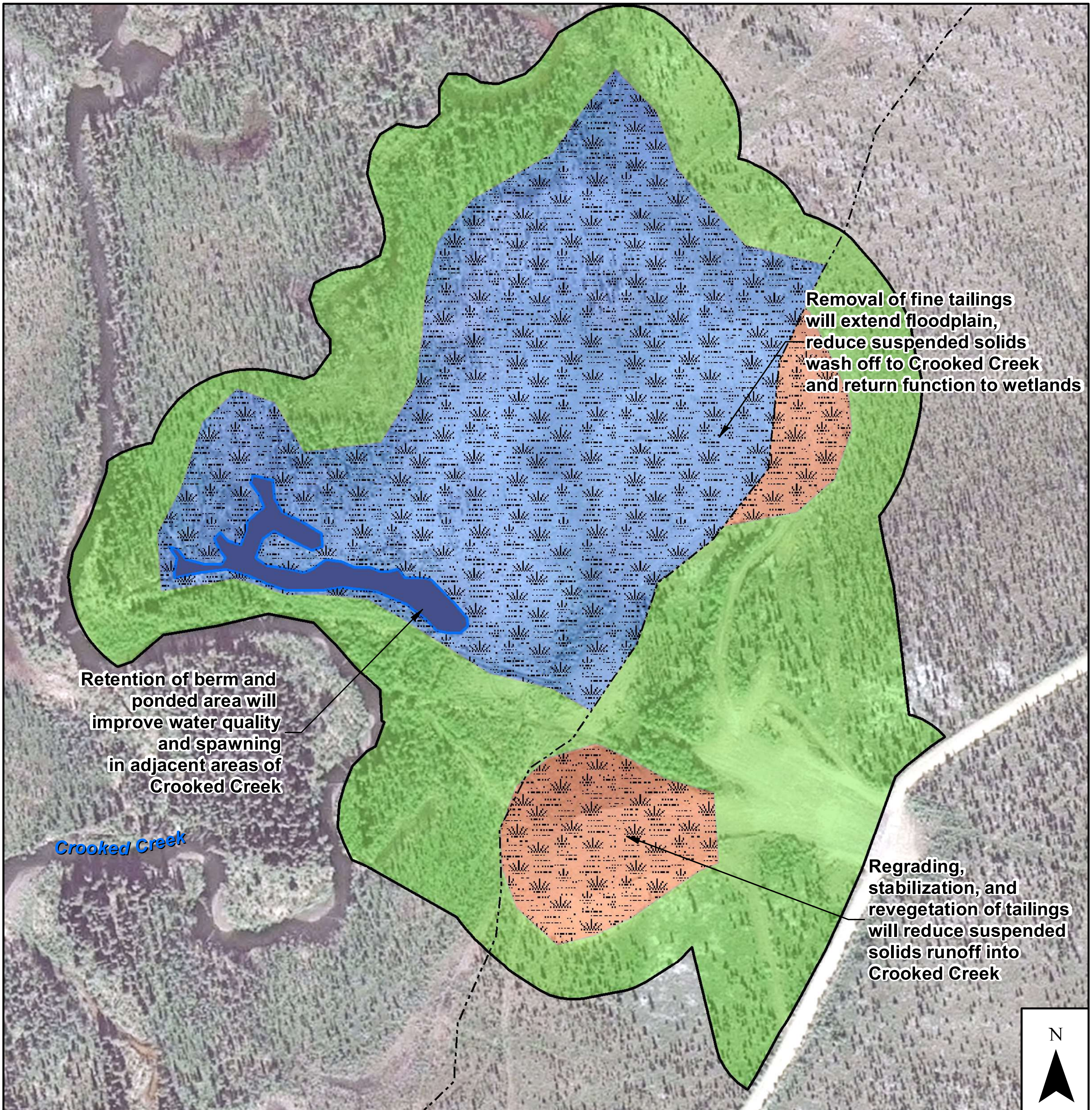
Compensatory Mitigation Plan Attachment D, Upper Crooked Creek PRM Plan, Appendix D-1

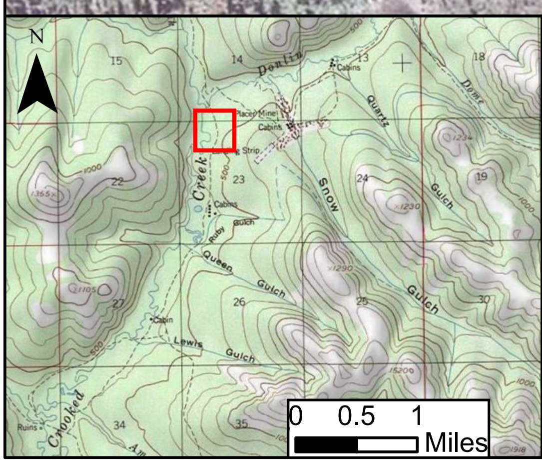
Wash Plant Tailings Construction Plan

NAD 1983 UTM Zone 4N;
Imagery 0.5 m resolution, capture date 5/29/2016

DONLIN GOLD

Figure 9





0 200 400
Feet

Flood Plain Boundary

Restoration Activity

- Re-established Floodplain
- Enhanced Terrestrial Habitat
- Protection Buffer
- Enhanced Off-channel Pond Habitat
- Revegetation Area

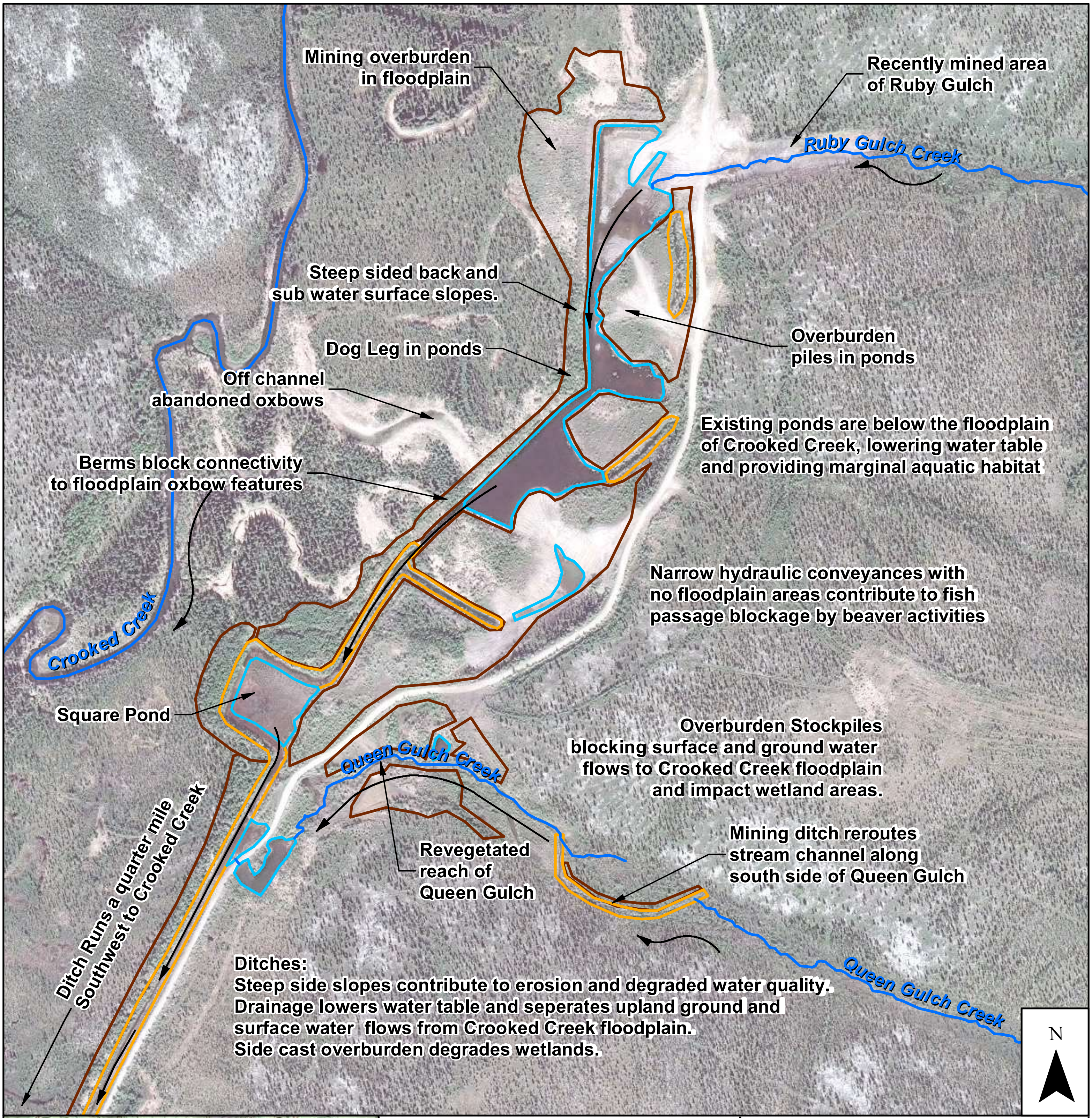
Compensatory Mitigation Plan
Attachment D, Upper Crooked
Creek PRM Plan, Appendix D-1

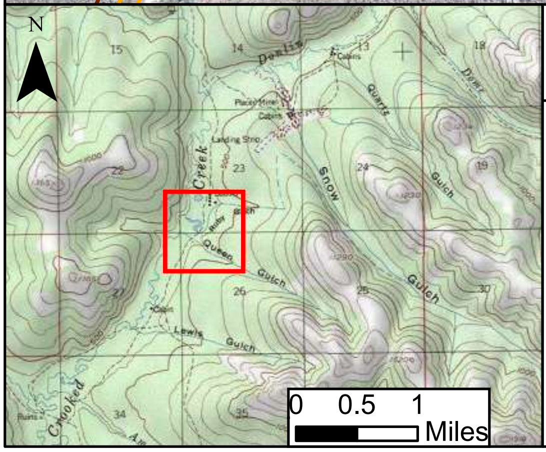
Wash Plant Post-Construction

NAD 1983 UTM Zone 4N;
Imagery 0.5 m resolution, capture date 5/29/2016

DONLIN GOLD

Figure 10





0 400 800 Feet

Existing Site Features

- Ditch
- Overburden
- Pond
- Existing Streams
- FlowPath

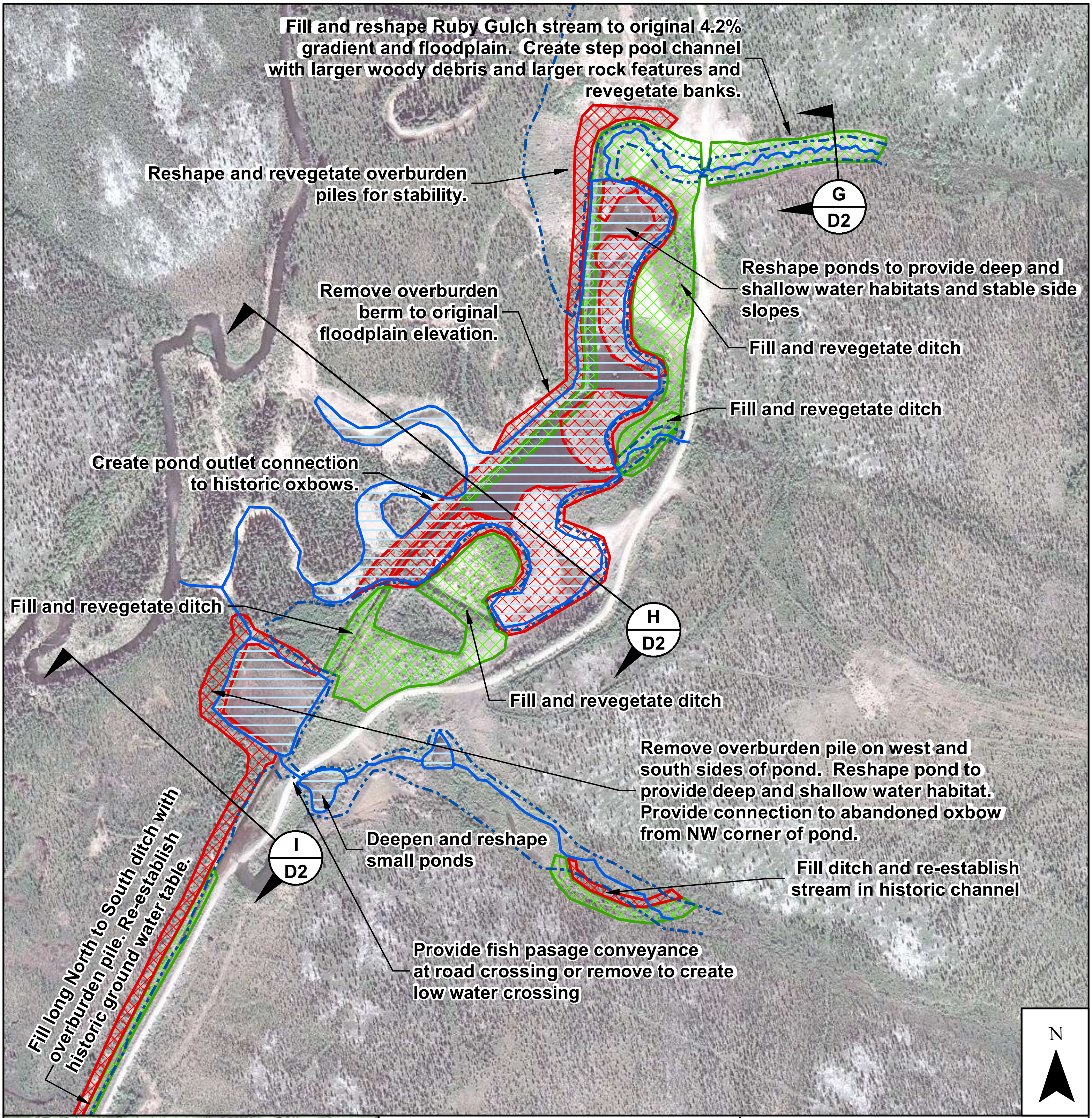
Compensatory Mitigation Plan Attachment D, Upper Crooked Creek Plan, Appendix D-1

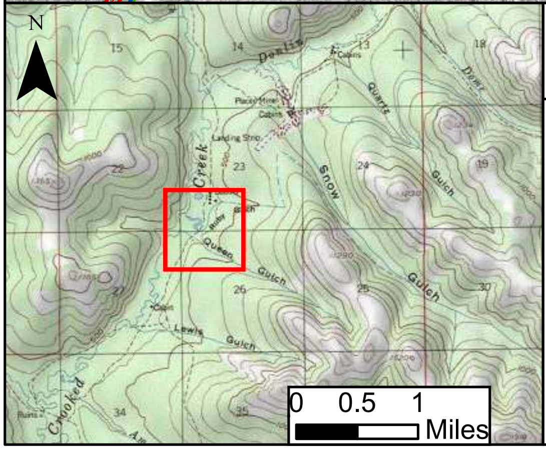
Ruby Queen Baseline Conditions

NAD 1983 UTM Zone 4N;
Imagery 0.5 m resolution, capture date 5/29/2016

DONLIN GOLD

Figure 11





0 400 800 Feet

Grading Plan

- Regrade Cut
- Regrade Fill
- Proposed Flood Plain Boundary
- Proposed Stream Thalweg
- Proposed Pond

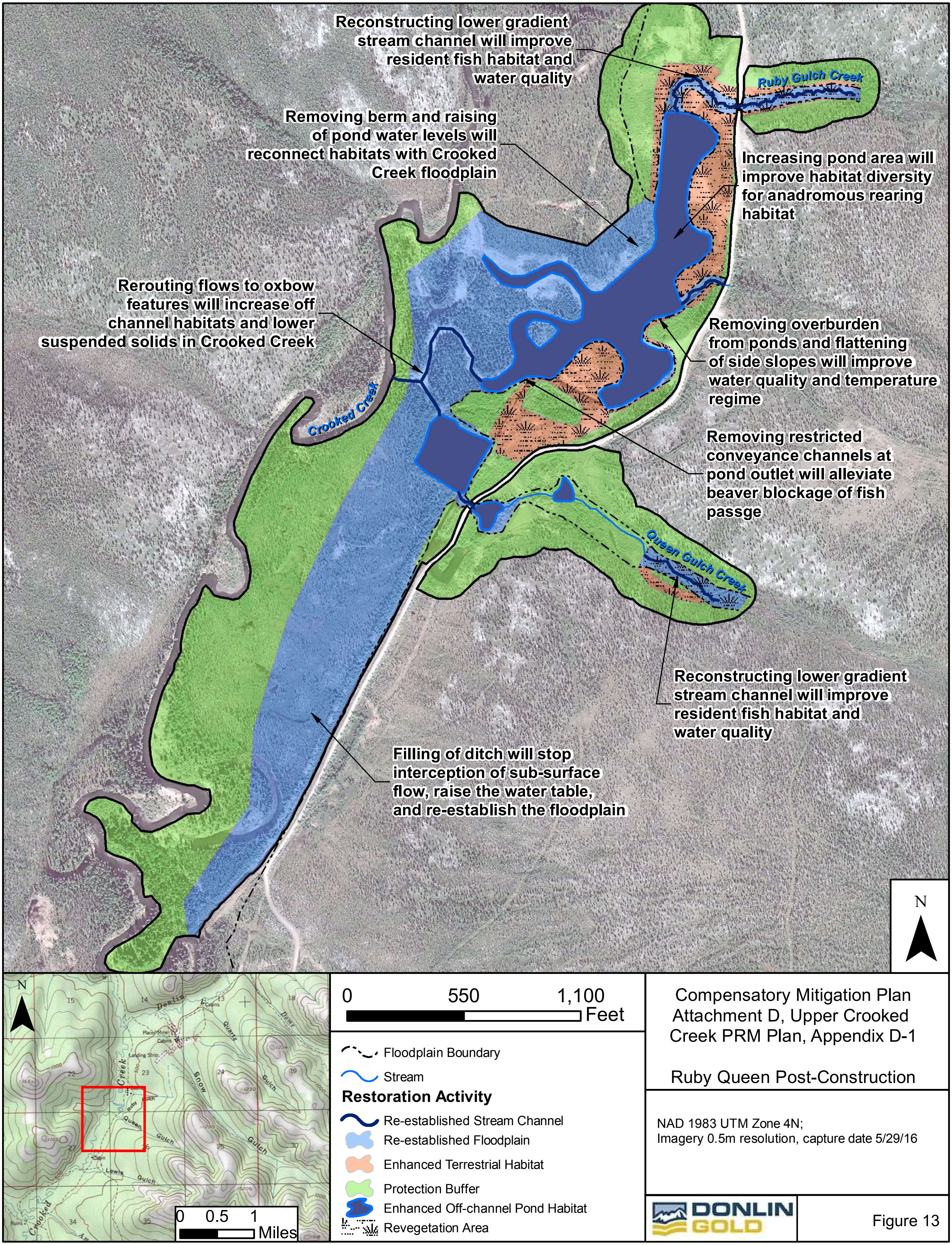
Compensatory Mitigation Plan
Attachment D, Upper Crooked Creek PRM Plan, Appendix D-1

Ruby Queen Construction Plan

NAD 1983 UTM Zone 4N;
Imagery 0.5m resolution, capture date 5/29/16

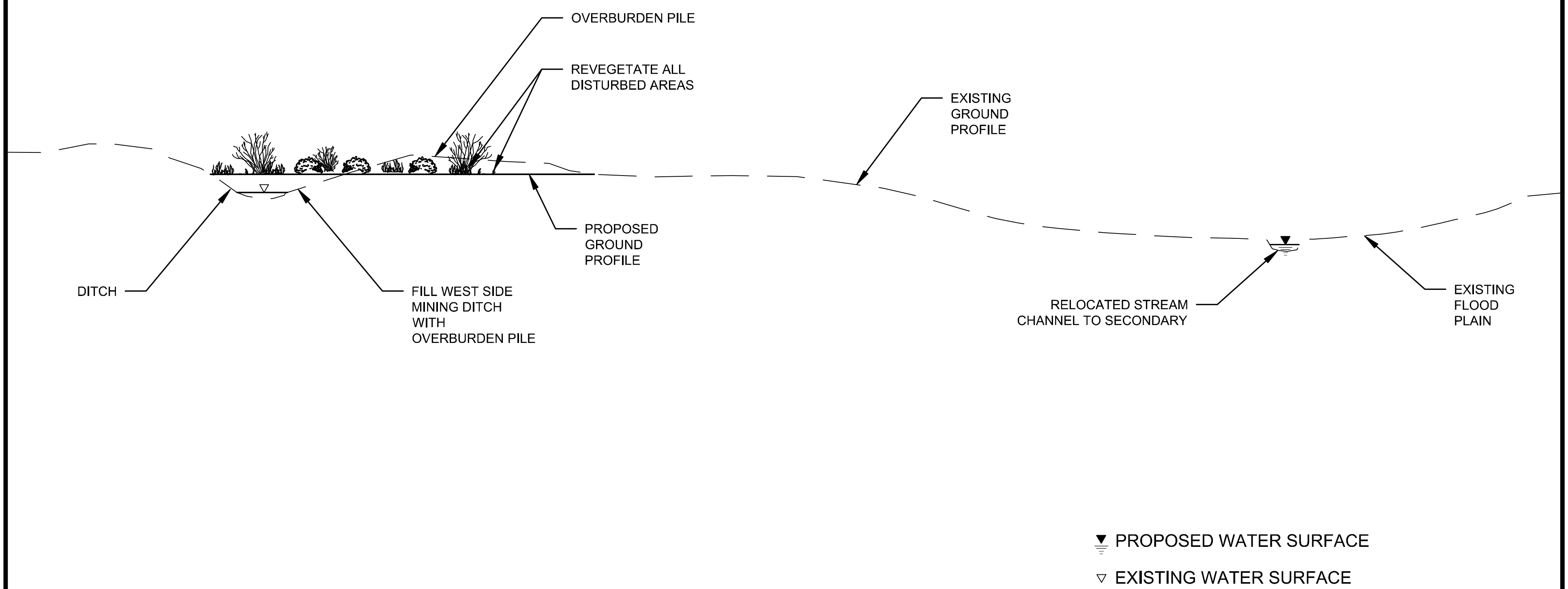
DONLIN GOLD

Figure 12



Reconstructing lower gradient stream channel will improve resident fish habitat and water quality
Ruby Gulch Creek
Removing berm and raising of pond water levels will reconnect habitats with Crooked Creek floodplain
Increasing pond area will improve habitat diversity for anadromous rearing habitat
Rerouting flows to oxbow features will increase off channel habitats and lower suspended solids in Crooked Creek
Removing overburden from ponds and flattening of side slopes will improve water quality and temperature regime
Crooked Creek
Removing restricted conveyance channels at pond outlet will alleviate beaver blockage of fish passge
Queen Gulch Creek
Reconstructing lower gradient stream channel will improve resident fish habitat and water quality
Filling of ditch will stop interception of sub-surface flow, raise the water table, and re-establish the floodplain
N
N
0 0.5 1
Miles
0 550 1,100
Feet
Floodplain Boundary
Stream
Restoration Activity
Re-established Stream Channel
Re-established Floodplain
Enhanced Terrestrial Habitat
Protection Buffer
Enhanced Off-channel Pond Habitat
Revegetation Area
Compensatory Mitigation Plan Attachment D, Upper Crooked Creek PRM Plan, Appendix D-1
Ruby Queen Post-Construction
NAD 1983 UTM Zone 4N;
Imagery 0.5m resolution, capture date 5/29/16
DONLIN GOLD
Figure 13

Appendix D-2



DONLIN GOLD

UPPER QUARTZ GULCH TYPICAL SECTION A

Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale. Vertical exaggerated to show detail.

All section cuts taken facing in downstream direction.

Surface data in feet derived from ArcticDEM 2m.

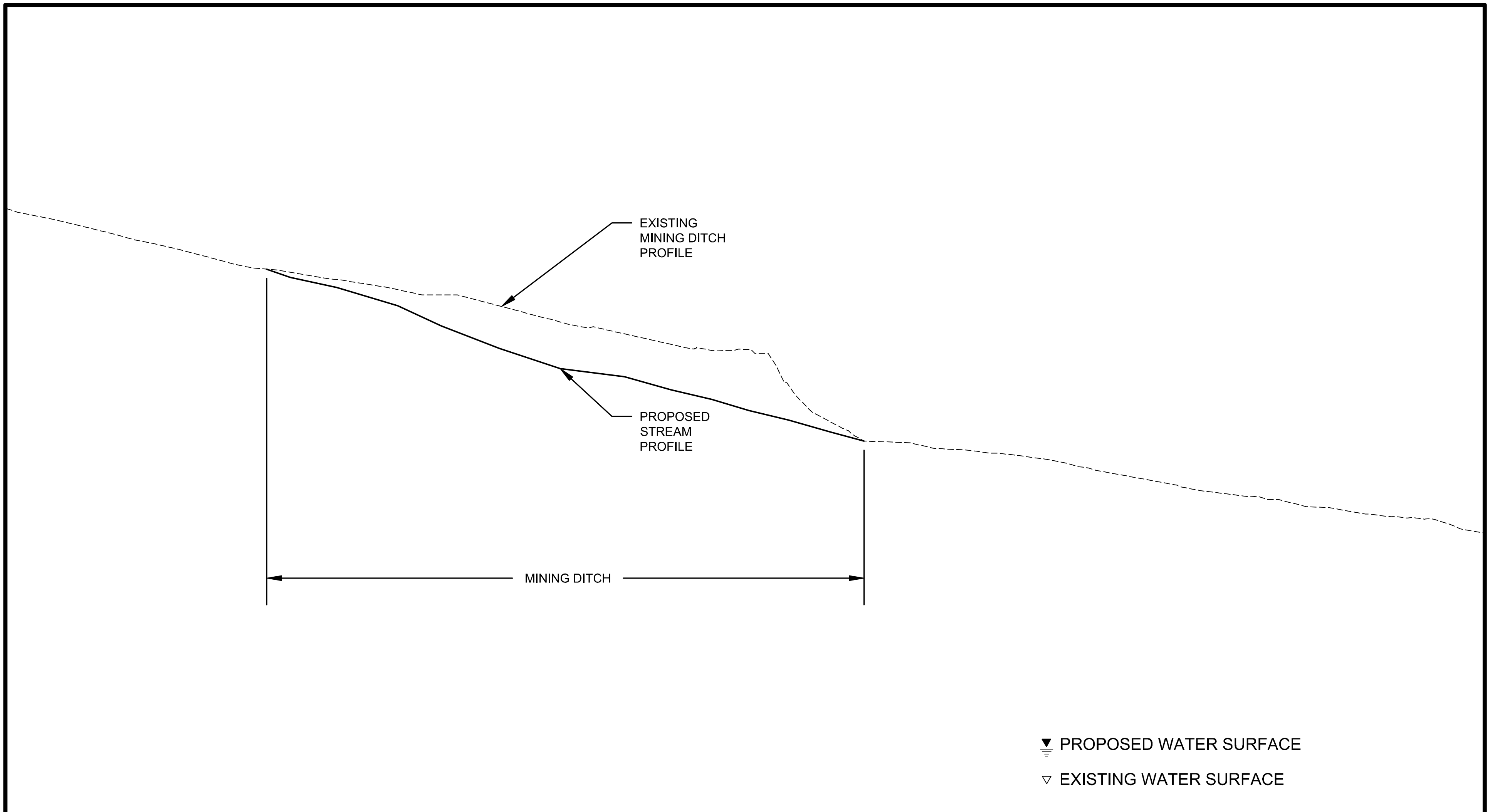
Compensatory Mitigation Plan

UPPER QUARTZ GULCH REMEDIATION

Drawn By: SRB

Date: 5/22/18

APPENDIX D-2 | SHEET 1



DONLIN GOLD

UPPER QUARTZ GULCH PROFILE B

Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale. Vertical exaggerated to show detail.

All section cuts taken facing in downstream direction.

Surface data in feet derived from ArcticDEM 2m.

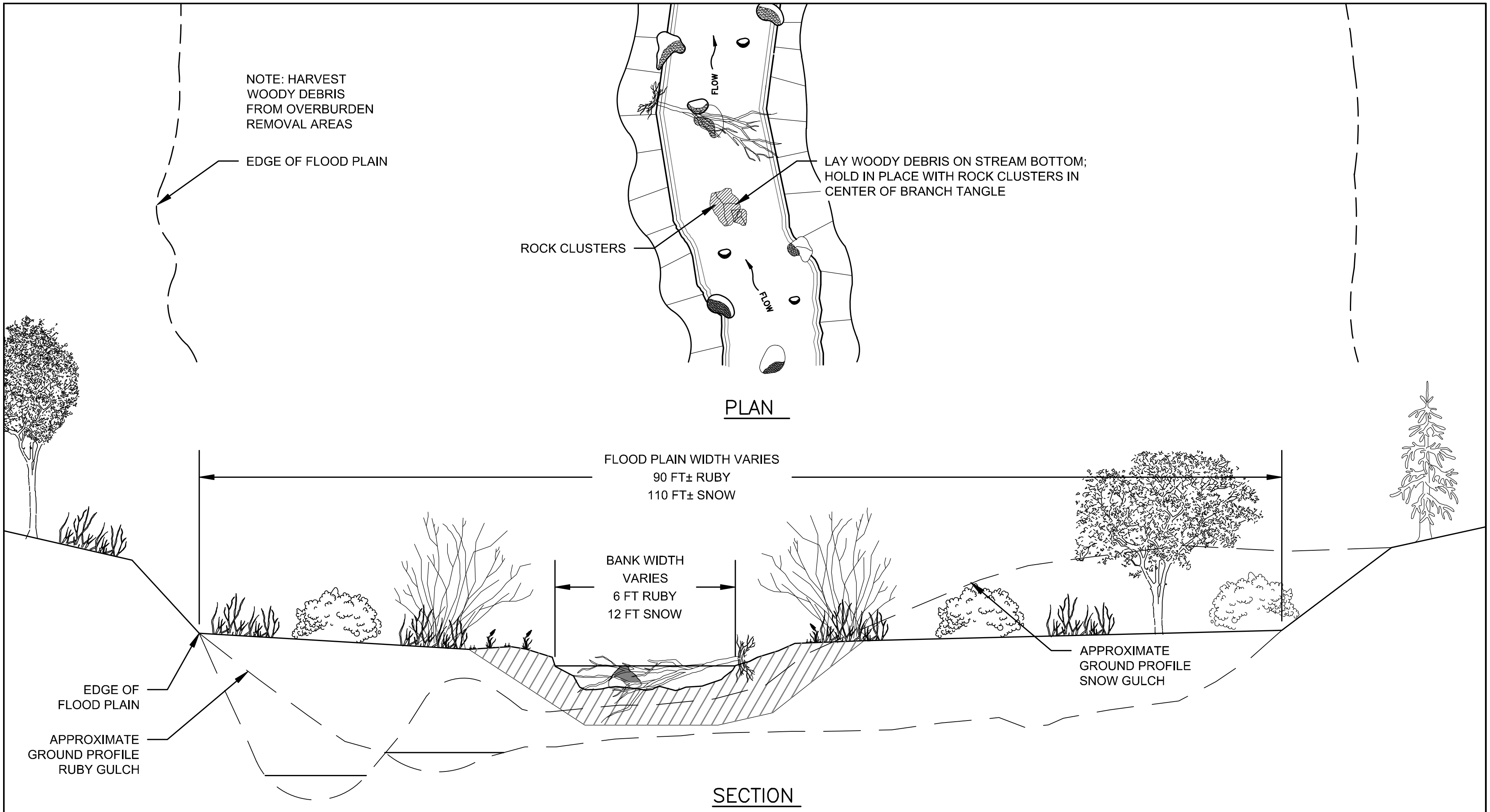
Compensatory Mitigation Plan

UPPER QUARTZ GULCH RESTORATION

Drawn By: SRB

Date: 6/6/18

APPENDIX D-2 | SHEET 2



DONLIN GOLD

TYPICAL RESTORATION CHANNEL PLAN & SECTION

Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale. Vertical exaggerated to show detail.

All section cuts taken facing in downstream direction.

Surface data in feet derived from ArcticDEM 2m.

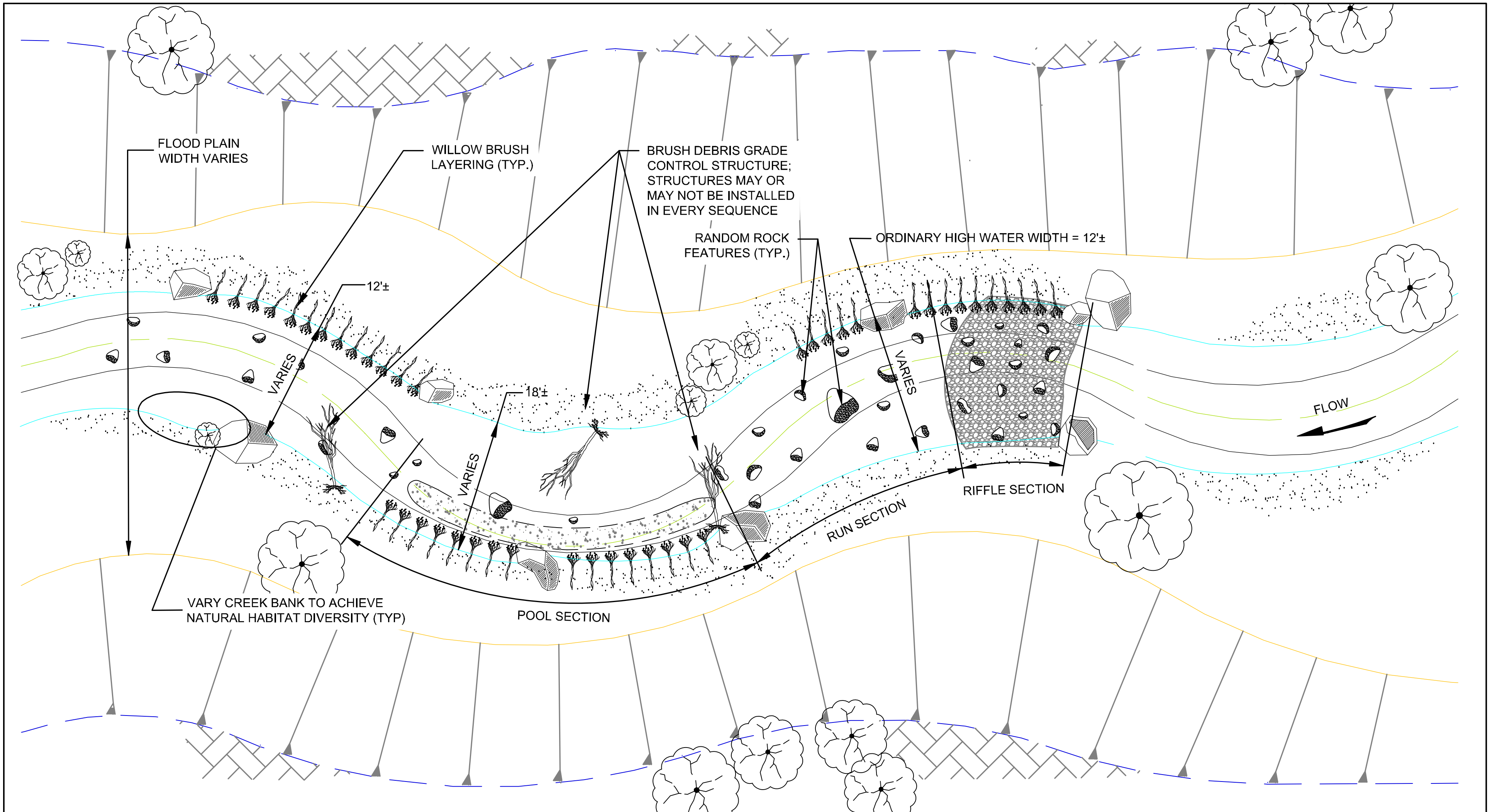
Compensatory Mitigation Plan

TYPICAL CHANNEL DETAILS

Drawn By: SRB

Date: 6/6/18

APPENDIX D–2 | SHEET 3



DONLIN GOLD

TYPICAL STREAM CHANNEL PLAN, RIFFLE–RUN–POOL

Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale.

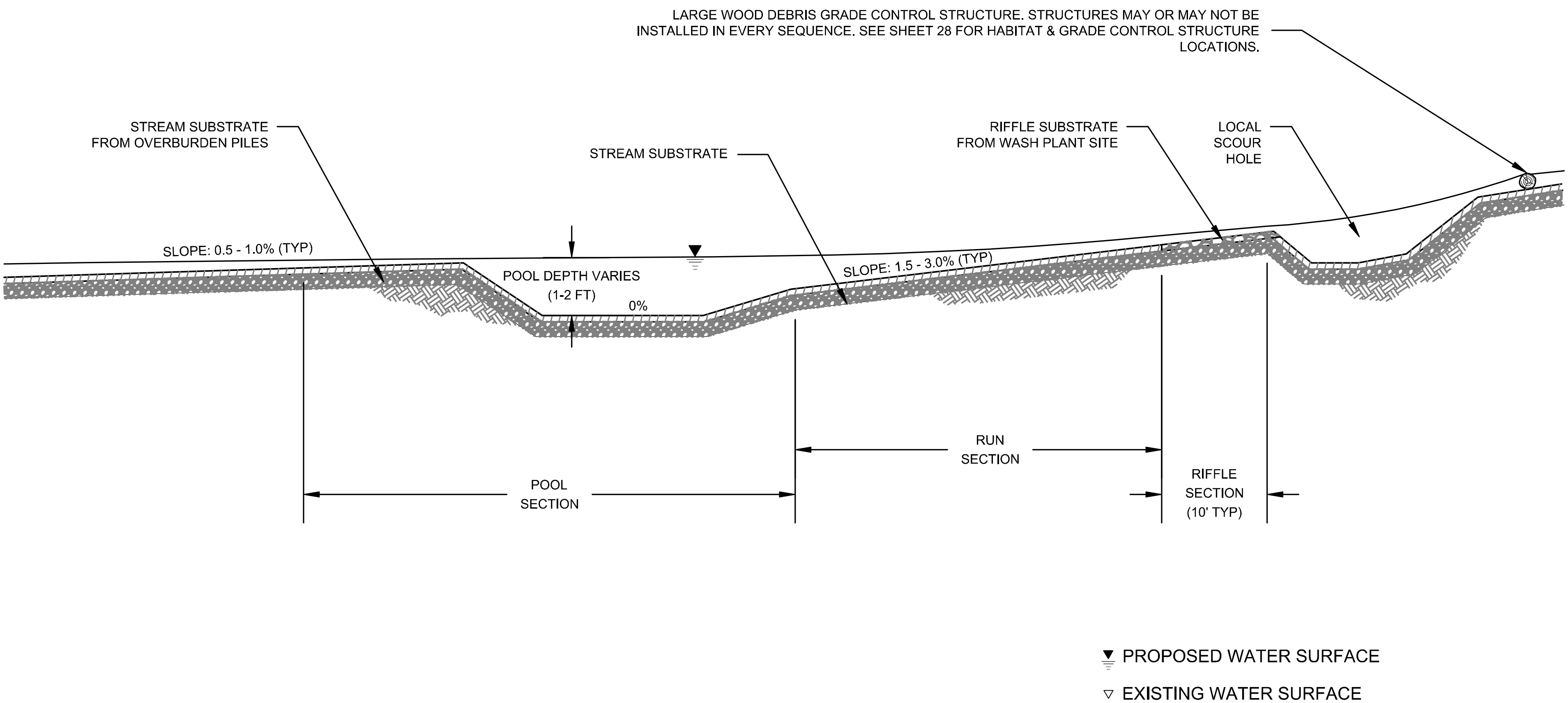
Compensatory Mitigation Plan

TYPICAL RIFFLE–RUN–POOL PLAN

Drawn By: SRB

Date: 6/6/18

APPENDIX D–2 | SHEET 4



TYPICAL STREAM CHANNEL PROFILE, RIFFLE–RUN–POOL

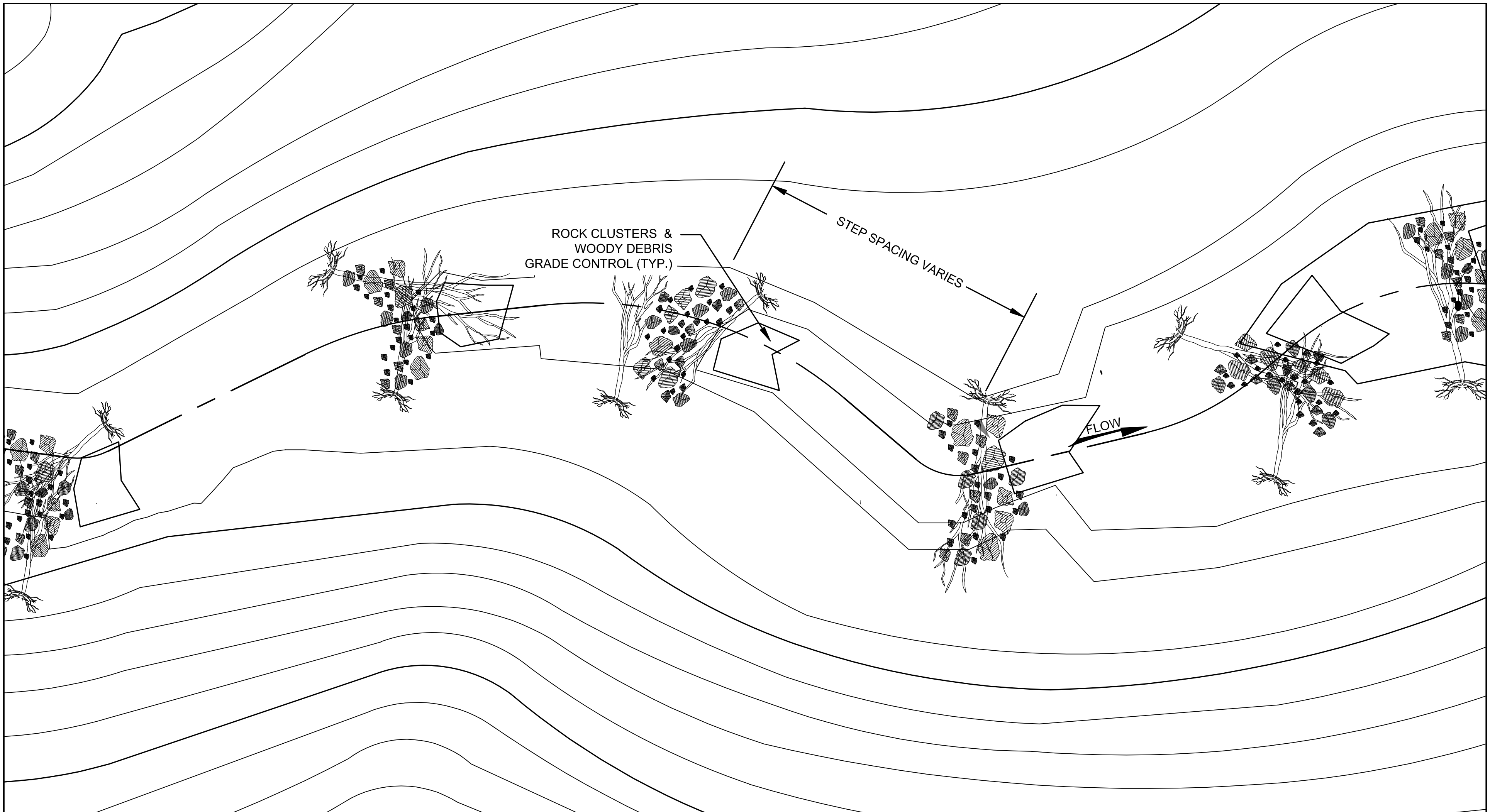
Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale. Vertical exaggerated to show detail.

All section cuts taken facing in downstream direction.

Surface data in feet derived from ArcticDEM 2m.

Compensatory Mitigation Plan	
TYPICAL RIFFLE–RUN–POOL PROFILE	
Drawn By: SRB	
Date: 6/6/18	
APPENDIX D–2	SHEET 5



DONLIN GOLD

TYPICAL STREAM CHANNEL PLAN, STEP–POOL

Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale. Vertical exaggerated to show detail.

All section cuts taken facing in downstream direction.

Surface data in feet derived from ArcticDEM 2m.

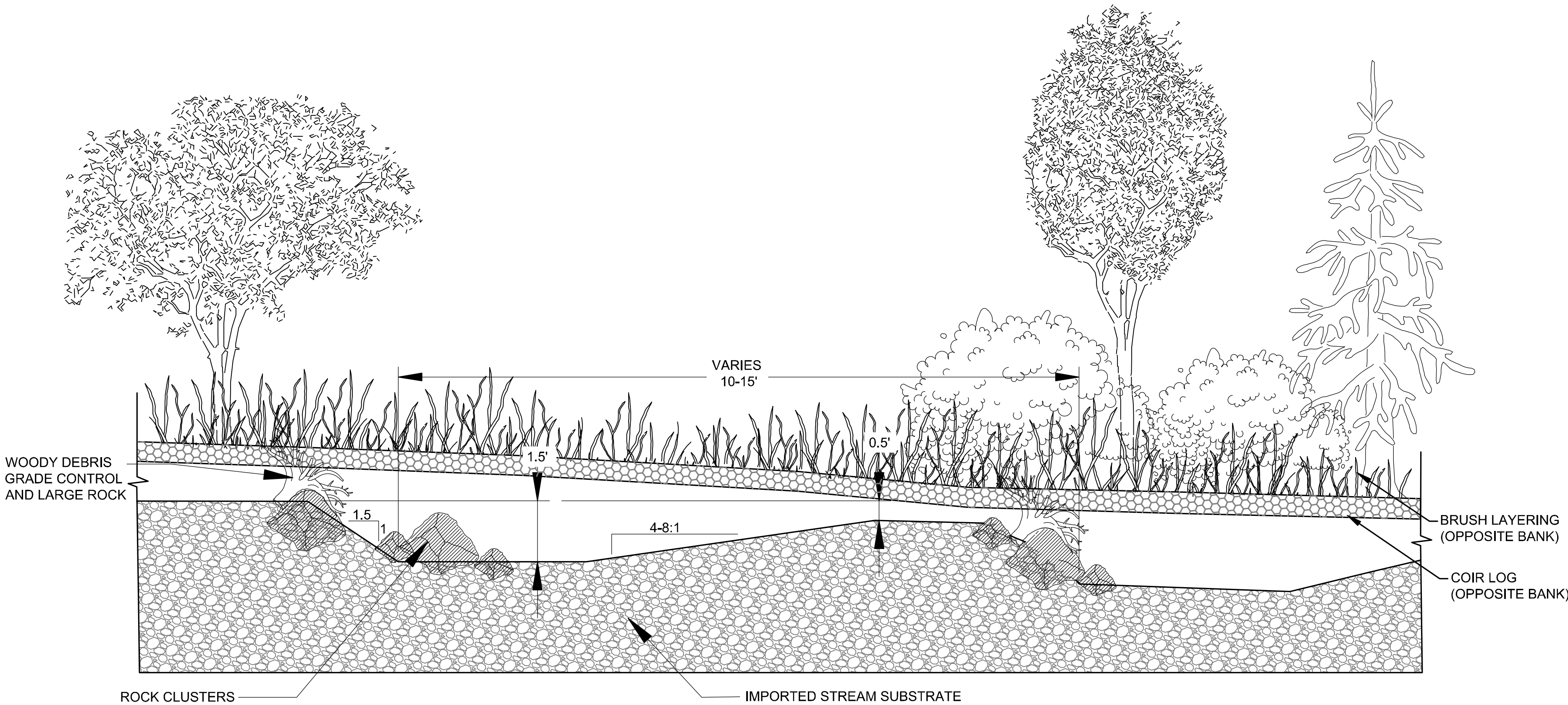
Compensatory Mitigation Plan

RUBY GULCH RESTORATION

Drawn By: SRB

Date: 6/6/18

APPENDIX D–2 | SHEET 6



DONLIN GOLD

TYPICAL STREAM CHANNEL PROFILE, STEP–POOL

Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale. Vertical exaggerated to show detail.

All section cuts taken facing in downstream direction.

Surface data in feet derived from ArcticDEM 2m.

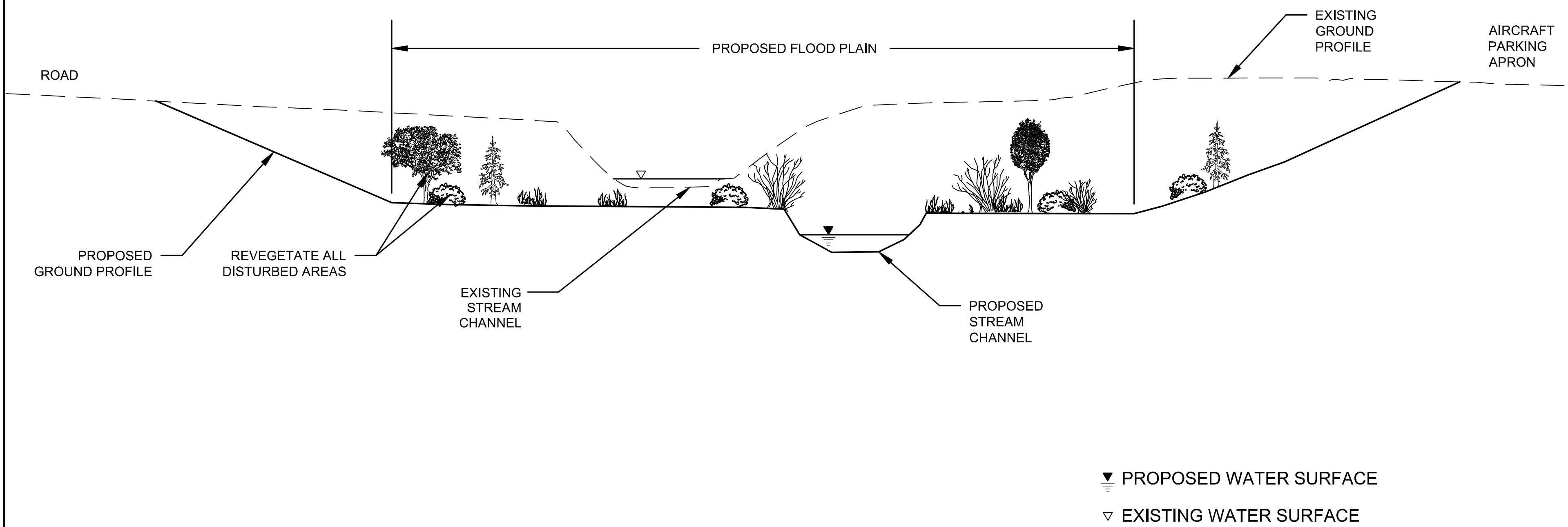
Compensatory Mitigation Plan

RUBY GULCH RESTORATION

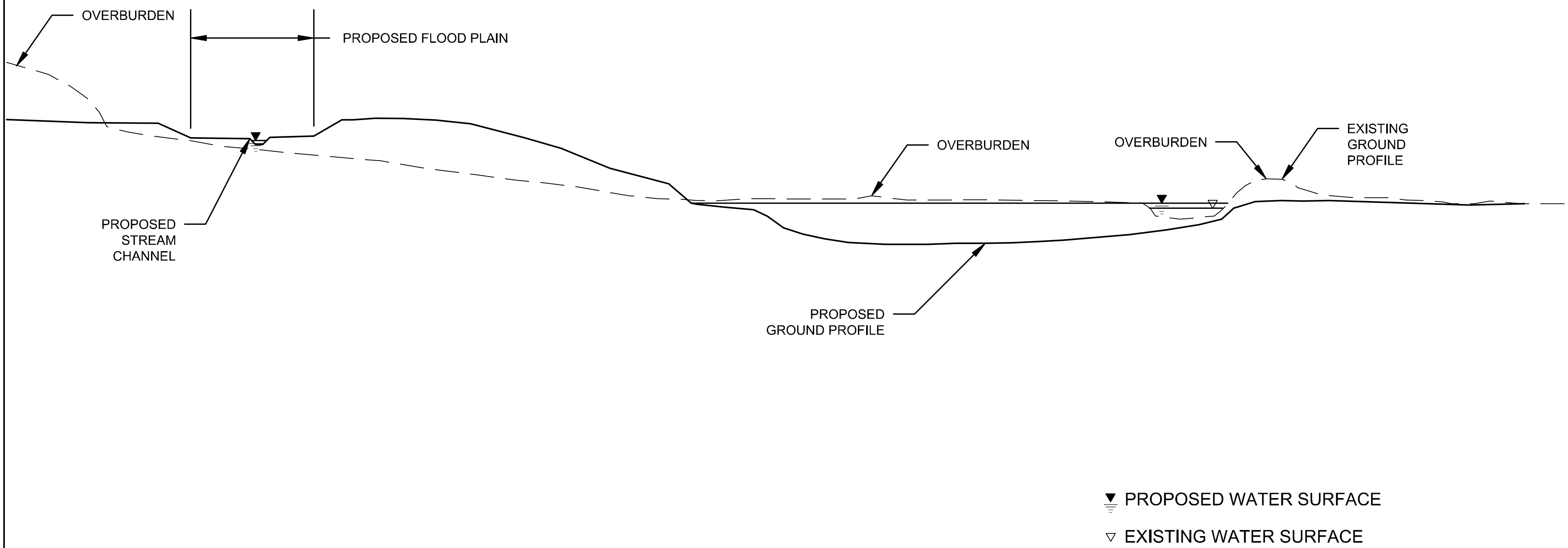
Drawn By: SRB

Date: 6/6/18

APPENDIX D–2 | SHEET 7



DONLIN GOLD	SNOW GULCH TYPICAL SECTION C	Compensatory Mitigation Plan SNOW GULCH RESTORATION
	Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities. Drawing is not to scale. Vertical exaggerated to show detail. All section cuts taken facing in downstream direction. Surface data in feet derived from ArcticDEM 2m.	Drawn By: SRB Date: 6/6/18
		APPENDIX D–2 | SHEET 8



DONLIN GOLD

SNOW GULCH POND SECTION D

Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale. Vertical exaggerated to show detail.

All section cuts taken facing in downstream direction.

Surface data in feet derived from ArcticDEM 2m.

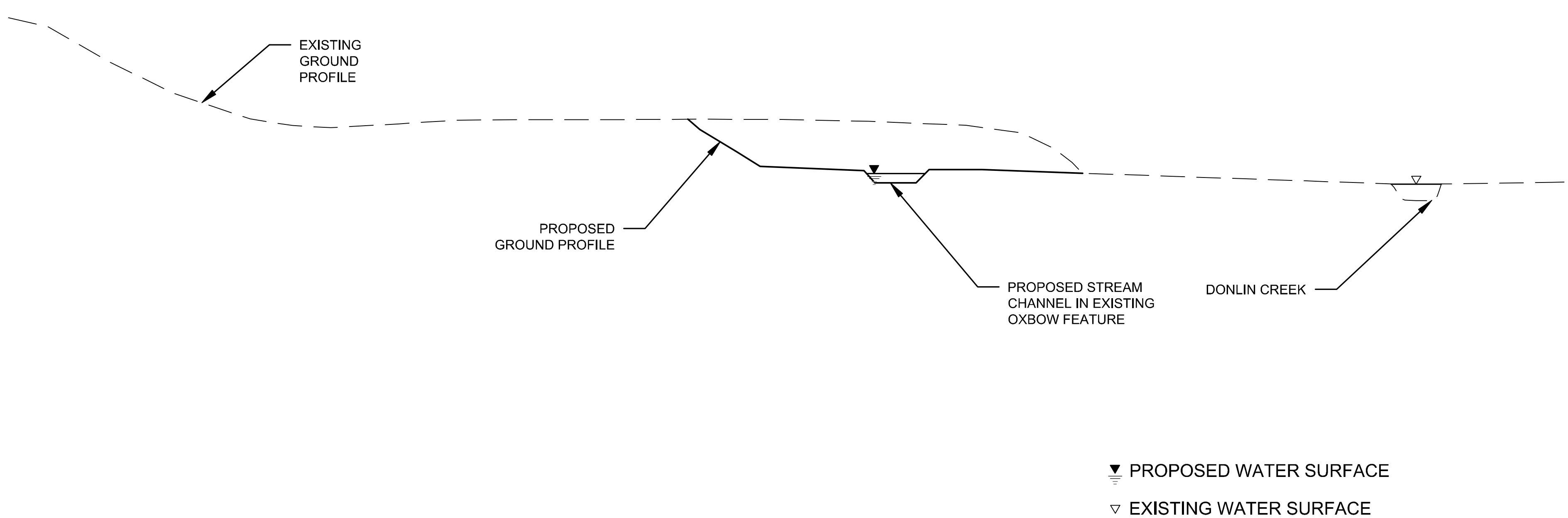
Compensatory Mitigation Plan

SNOW GULCH POND SECTION

Drawn By: SRB

Date: 6/6/18

APPENDIX D–2 | SHEET 9



DONLIN GOLD

SNOW GULCH & DONLIN CREEK SECTION E

Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale. Vertical exaggerated to show detail.

All section cuts taken facing in downstream direction.

Surface data in feet derived from ArcticDEM 2m.

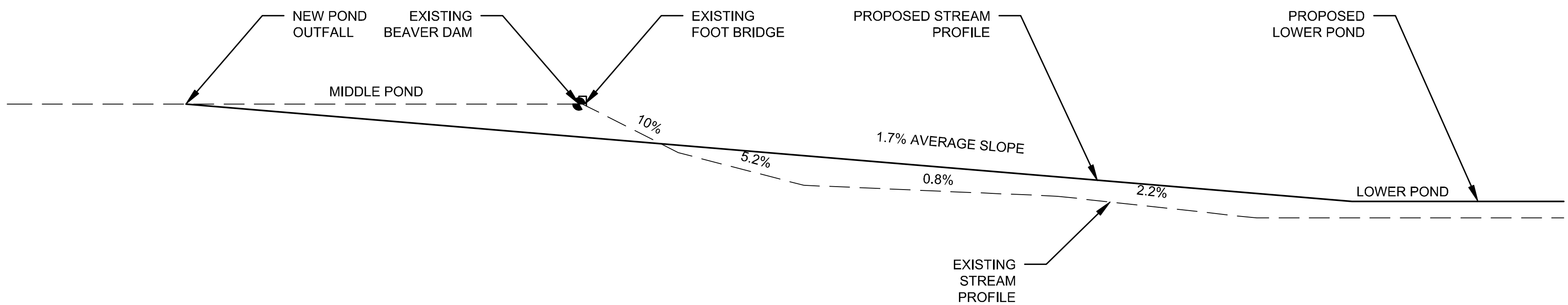
Compensatory Mitigation Plan

SNOW GULCH RESTORATION

Drawn By: SRB

Date: 6/6/18

APPENDIX D–2 | SHEET 10



DONLIN GOLD

SNOW GULCH PROFILE F

Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale. Vertical exaggerated to show detail.

All section cuts taken facing in downstream direction.

Surface data in feet derived from ArcticDEM 2m.

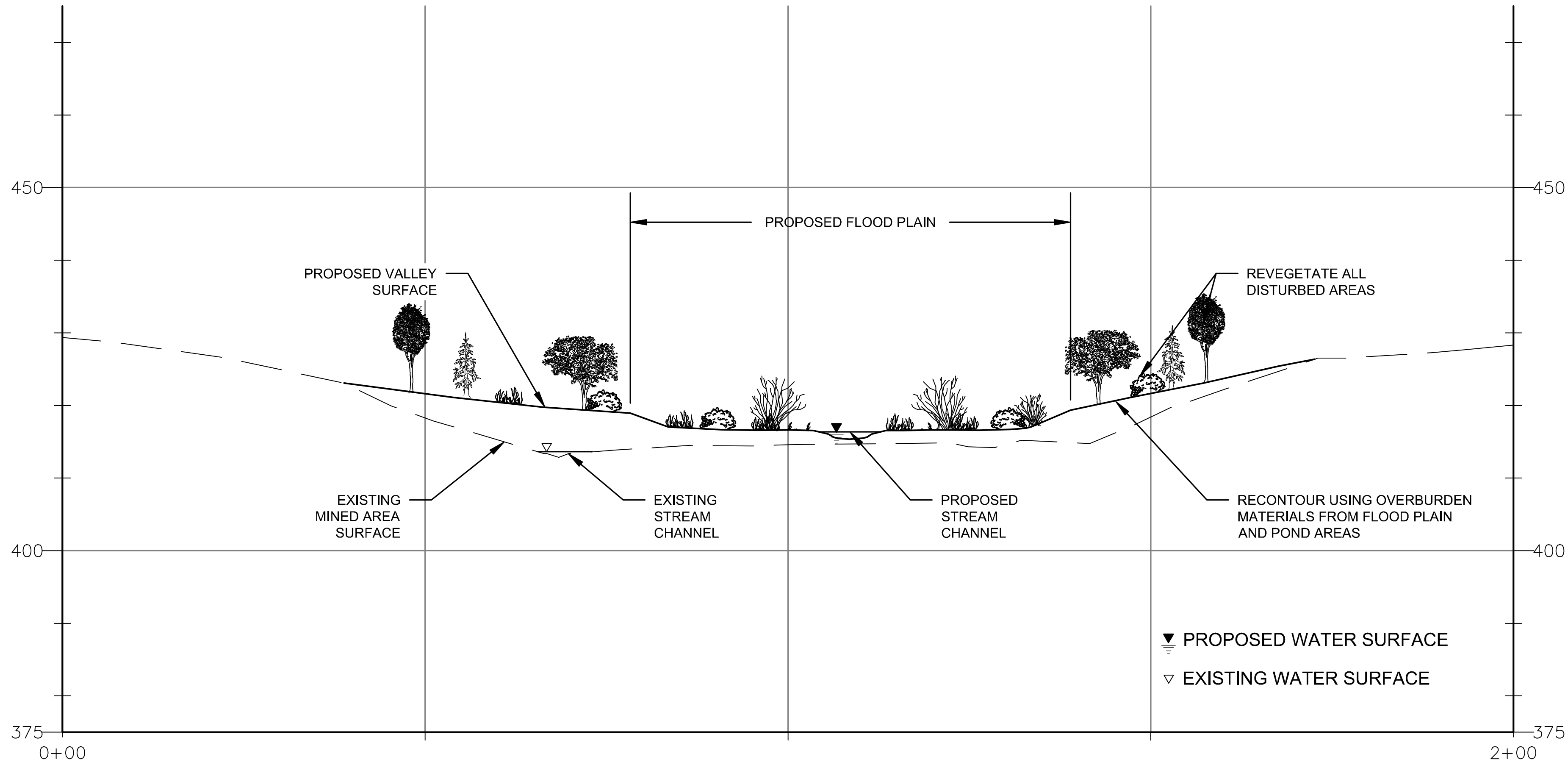
Compensatory Mitigation Plan

SNOW GULCH STREAM BED PROFILE

Drawn By: SRB

Date: 6/6/18

APPENDIX D–2 | SHEET 11



DONLIN GOLD

RUBY GULCH TYPICAL SECTION G

Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale. Vertical exaggerated to show detail.

All section cuts taken facing in downstream direction.

Surface data in feet derived from ArcticDEM 2m.

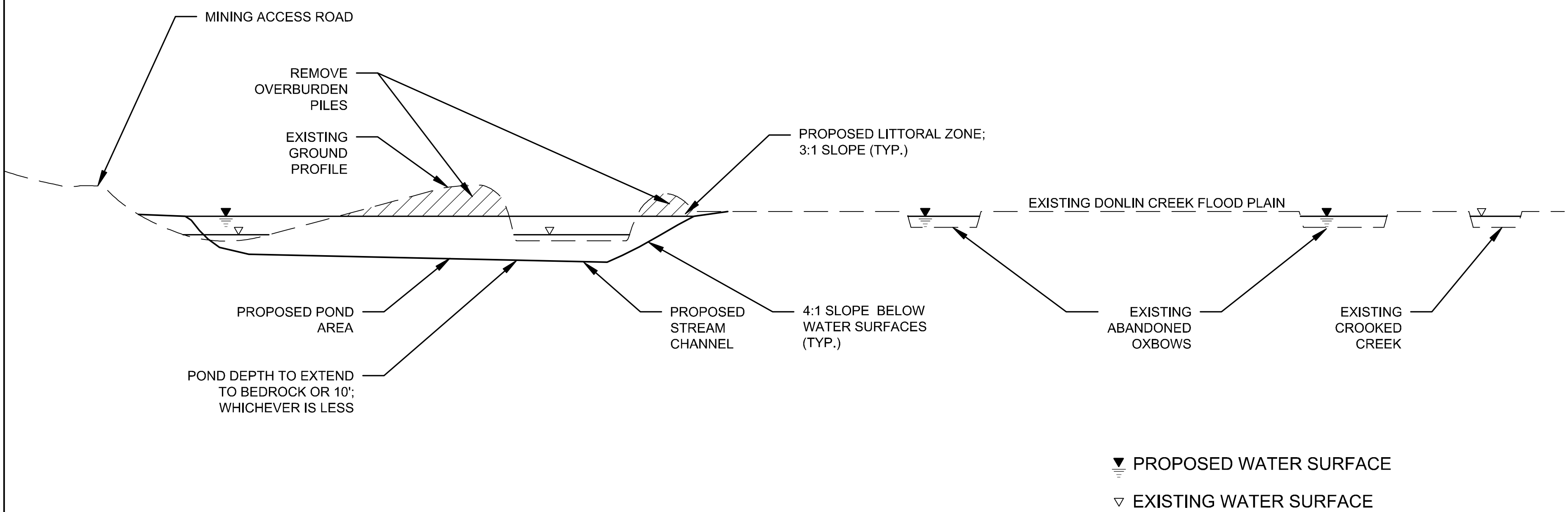
Compensatory Mitigation Plan

RUBY GULCH RESTORATION

Drawn By: SRB

Date: 6/6/18

APPENDIX D–2 | SHEET 12



DONLIN GOLD

RUBY–QUEEN TYPICAL SECTION H

Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities.

Drawing is not to scale. Vertical exaggerated to show detail.

All section cuts taken facing in downstream direction.

Surface data in feet derived from ArcticDEM 2m.

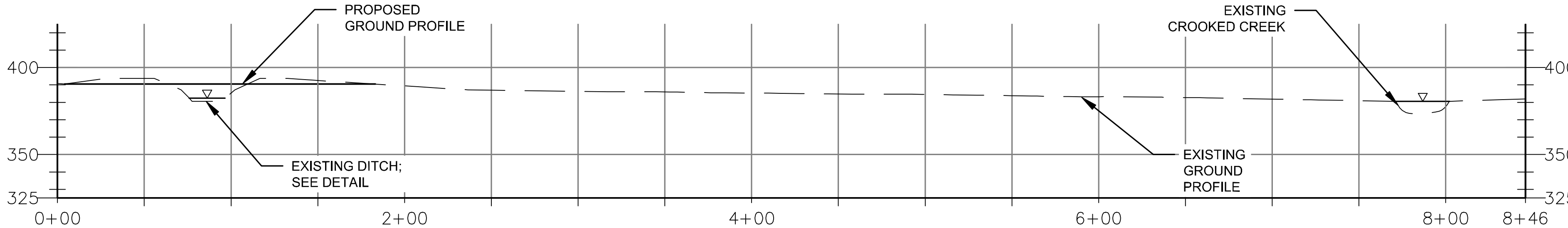
Compensatory Mitigation Plan

RUBY–QUEEN RESTORATION

Drawn By: SRB

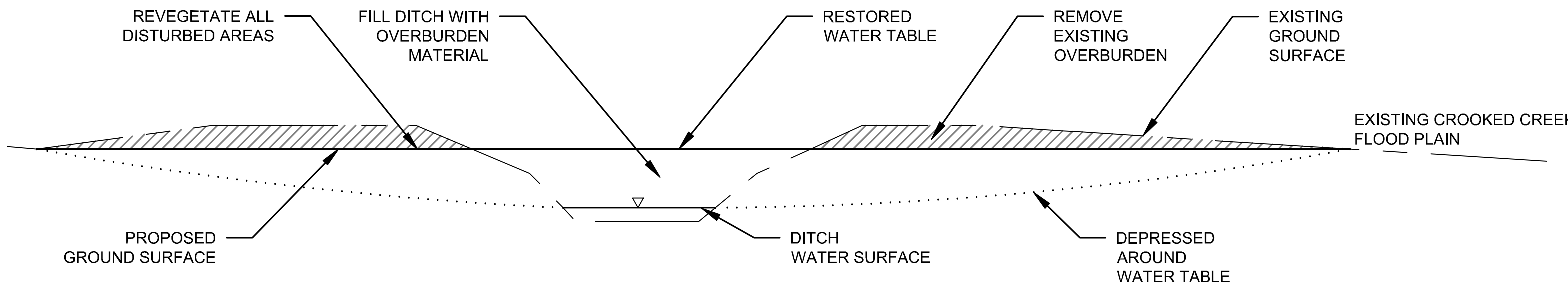
Date: 6/6/18

APPENDIX D–2 | SHEET 13



▽ EXISTING WATER SURFACE

DITCH TYPICAL SECTION



DITCH DETAIL

DONLIN GOLD	RUBY–QUEEN DITCH SECTION I	Compensatory Mitigation Plan RUBY–QUEEN RESTORATION
	Notes: Not for construction. Plans are conceptual and require field verification prior to restoration activities. Drawing is not to scale. Vertical exaggerated to show detail. All section cuts taken facing in downstream direction. Surface data in feet derived from ArcticDEM 2m.	Drawn By: SRB Date: 6/6/18 APPENDIX D–2	SHEET 14